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THE USES OF ELEVATED TANKS IN WATER SUPPLY SYSTEMS[1]

By George H. Fenkell[2]

As the quantity production of large pipes, capable of withstanding even moderate pressures, is a comparatively recent development of industry, a gravity supply of water, until not long ago, was delivered with uninterrupted flow through open conduits and tunnels. When it became necessary, to control and conserve the supply by storage, gates were utilized, and when in recent times pipe took the place of the open conduit the use of control valves was introduced. Control valves have been found troublesome to maintain where excessive water pressures, due to surges, have been experienced when the valves were manipulated.

While a gravity supply of water for a community was for a long period of time the only method that could be considered and is now one to be desired, by far the greater portion of the cities that are located on the Mississippi water shed must be supplied through the use of pumping equipment.

The present era of the water works utility began with the development of the steam engine as a prime mover, and with the establishment of the industry which made possible the manufacture in an

[1] Presented before the Indiana Section meeting, March 15, 1928.

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economical manner of cast iron pipes. The progress in the improvement of the steam engine for this service was slow, and until about seventy-five years ago large steam pumping engines used for water works purposes, while operated condensing, were but adaptations of the pumps that were used in England for de-watering mines, the use of which had been introduced in that country as early as the 18th century. A single vertical steam cylinder was used, the steam was admitted only beneath the piston, and the return stroke was accomplished through the use of weights. More recently important advances were made in the development of the pumping engine, and about thirty-five years ago the use of the triple expression engine for large pumping units came into quite general use.

The types of steam pumps that were made available about 1890 were very reliable in operation and flexible in meeting the demands for water. With the use of water passages of ample size, and with an abundant number of water valves of ample area, these pumps could be operated in regular practice from about 10 per cent above normal capacity to about one-third below normal capacity, and at pressures one-third above normal to nearly 50 per cent below, with but little reduction in economy, the range of operation depending upon the design. In earlier installations of pumps having only a single cylinder, water hammer became troublesome, and even with the introduction of the triple expansion pumps this difficulty was not at first overcome entirely. The reason for this was because at that time the effect and underlying principles of operation of air chambers were not well understood, and even when these were well proportioned, the possibility always existed that the operator would fail to maintain in them the quantity of air that good practice demanded.

Nearly every water system includes in its design a reservoir of a considerable capacity, provided a convenient site can be obtained which has the desired area and elevation, but unfortunately many cities are so located that no land can be obtained that meets these requirements. In order to reduce water hammer or surges to a minimum, and to maintain a reserve supply whenever there was an interruption of pumping service, or whenever an abnormal demand for water existed, provision in the design of many water systems was made for stand pipes or elevated tanks, and these were located at or near the pumping stations.

Not a few water works plants were operated quite satisfactorily without resorting to the elevated storage of water, and some of these

were of a large capacity and were served from a single pumping station. More recently it has been found that the use of a stand pipe near the pumping station may increase surges rather than decrease them, and that its effect is dependant upon its location and method of connection as well as on the design of the stand pipe. Tanks are used quite generally by large consumers to guard against interruption of service, whether the cause of the anticipated trouble is at the pumping station; with the large mains; or of a local nature; and also to allow larger quantities of water to be drawn for a short time by the consumer than would otherwise be available. Formerly stand pipes were frequently used for the elevated storage of water, but since about 1910 but few have been constructed because of the great danger of failure and the fact that for the service rendered the elevated tank is somewhat cheaper to construct and maintain, and is generally less unsightly.

During the past few years there has been a very decided change in the design of pumping units. Steam turbine driven contrifugal pumps are frequently installed in existing steam stations. Without entering into a discussion of the relative costs of reciprocating and centrifugal pumps, the fact remains that few of the former are now being placed in service, while the latter have come into very general use. The use of the centrifugal pump has introduced a number of problems that are of prime interest in design and operation. The centrifugal pump is less elastic in operation, for it does not as easily meet the consumption demand which varies from hour to hour. This is particularly true of the motor driven pump, whose use is increasing rapidly, because of the quite reliable service at reasonable rates that has been made available by the public service corporations. The lowest rates for current can be obtained usually through the use of the synchronous motor operating throughout the twenty-four-hour day.

As the electric service that is available in many towns is satisfactory, and as the centrifugal pump characteristics do not always permit that type of equipment to be used in a convenient or economical manner, consideration has been given by manufacturers to the use of the motor driven reciprocating pump.

In an endeavor to vary the discharge from a centrifugal pump so as to meet a changing demand or output, various expedients are resorted to. A steam turbine is used as a prime mover, although the duty obtained diminishes when it is operated at less than its rated capacity; the diesel engine is also used as the prime mover; the discharge line is

throttled; a bleeder or blow-off pipe is connected from the discharge pipe to the suction well; a variable speed induction motor is used; or additional pumps of similar and varying capacities are installed. "Oil engines are capable of satisfactory operation at one-half to full speed, but should not be expected to carry substantial overloads."[3] The resort to any of these methods for obtaining flexibility of output either increases the cost of the installation or of maintenance or of operation, over what it would have been were it possible to operate satisfactorily with a more constant discharge.

The steam reciprocating pump was well adapted for use with a widely fluctuating load, and has been displaced largely by the centrifugal pump, which is best fitted to operate at constant discharge and at uniform pressure. While this change in practice was taking place, there has come an increasing insistence from the consumers for better and more reliable service, both for ordinary and fire prevention use. In a community in which it has been found desirable to deliver the supply of water through the use of moter driven centrifugal pumps, it will be found that the synchronous motor can seldom be used except by throttling, or bleeding, or by the use of the elevated storage of water. Variable speed motors may be substituted, or a group of pumps may be installed in which both synchronous and variable speed motors are used. Constant speed motors may be either of the synchronous or induction type.

It should be stated here that general rules for the selection of the size, type and the method of control of pumps, and the determination of the capacity and location of storage tanks, can not be applied to a specific case with certainty. This is apparent for several reasons, some of which may be stated as follows:

a. The characteristics of different pumps will vary and depend on the design of the pumps;

b. The consumption of water for household purposes, and for manufacturing and commercial purposes, will vary from year to year as well as from hour to hour;

c. The topography of the area in which the town is located will determine to no small degree the design of the water system;

d. The size and location of existing pipes and structures are of primary interest in determining how an existing plant should be improved;

[3] "Water Works Practice," by American Water Works Association.

e. The cost and availability of fuel and electric current will be found to be quite different in different localities;

f. Water that is stored in an elevated tank for fire prevention use may be of considerable value;

g. The elevated storage of water tends to prevent brief interruptions of service, and while desirable for this purpose this use may be intangible

h. The maximum pressure that can be maintained safely at the pumping station may depend on the strength of such existing structures as pumps, mains, and household plumbing.

Estimates of cost have been prepared for comparative purposes, for pumping units of 5 and 10 m.g.d. capacities, with a head of 150 feet, as these are probably the size of units that would be used in cities having from 50,000 to 100,000 people. From these it is concluded that the investment for a synchronous motor driven centrifugal pump will be slightly more than for the induction motor driven centrifugal pump; and that the operating cost for constant capacity, head and speed are slightly less with the synchronous motor driven pump than with the induction motor drive. But for larger motor driven units, the relative investment cost for induction motor drive is more than for the synchronous motor drive. Moreover, the operating cost with synchronous motor drive is less than with the induction motor drive. When operating pumping units of 5 to 10 m.g.d. capacity at one-half capacity, the operating cost is slightly less when using a throttled discharge with a synchronous motor than with a variable speed induction motor. The use of a blow-off or bleeder for the return of water from the discharge pipe to the pump well for pressure and discharge control is found to be uneconomical.

The elevated storage of water in a proper location will effect a reduction in the operating costs at the pumping station, but this saving alone may not justify the expenditure required for the construction of the tank. In fact, this saving in operating costs is only one of the advantages that the tank makes possible, for this and others must be given due consideration:

a. Reduction of operating costs at the pumping station as mentioned above,

b. The maintenance of more uniform pressures throughout the year;

c. Reduction of capital costs for pumps and mains to meet the peak hour demand;

d. Improved fire service;

e. The maintenance of pressures during a short interruption of pumping service;

f. As pumping station attendants will not always operate the pumps in the most economical manner, there is an advantage from the use of a tank, as through its use less pump manipulation is required.

When ground water forms the source of supply, or when filtration of the water is resorted to, liberal storage capacity should be provided from which the distributing pumps can take their supply. This subject has been discussed by Arthur B. Morrill,[4] who points out the intimate relationship that exists between the size and cost of the filtration plant, and the capacity of a clear water reservoir; and further, that the elevated storage of a comparatively small quantity of water will very materially lessen the range of the quantity that must be discharged from the distributing pumping station. Likewise, there is also a close relationship between size and capacity of the pumps that are needed in a low lift pumping station and the amount of storage that is available for use in the coagulation basin which furnishes the supply to the filtration plant.

If it is assumed that the maximum hourly demand for the year is 1.8 times that of the average demand, and this is the ratio used by Mr. Morrill, and that no storage is provided at any point, then the low lift pumping station, filtration plant, distributing station, and mains, must be designed to meet this load, which is nearly double the average, and yet it is a demand which can come but once a year; and furthermore, the failure of any one of these elements for even a brief period of time would hinder the operation of all units. Storage in the coagulation basins and filter units that can be made use of in regular operation will simplify greatly the operation of the low lift station. The use of a reservoir near the pumping station for the storage of filtered water, or for ground water, should wells furnish the supply, and the use of an elevated tank for storage in the distribution system, will allow the distributing pumps to operate more economically, regularly and safely.

The cost of underground storage will depend upon the capacity, and upon the nature of the foundations and other local conditions. The cost of an elevated tank will also depend on the foundation requirements, but it may be expected that it will cost, exclusive of the cost of the site, and with an elevation at the top of 100 feet, from

[4] JOURNAL, November, 1926.

$10,000 for a 100,000 gallons tank, to $90,000 for a 1.5 million gallon tank. Smaller tanks will cost more proportionately. Only one tank with a capacity as great as 2 million gallons has been constructed so far, while four 1.5 million gallon tanks are nearing completion at Detroit.

Some of the matters that should be given careful consideration in the location and design of the tank have been well set forth by Nicholas S. Hill, Jr.[5] It is not always possible, however, to place the tank in its ideal location. Preferably it should be located on the side of the center of the district in which much of the water is consumed, opposite from the pumping station, near a main pipe line which is large enough to allow the tank to operate satisfactorily, and upon land that is as high or higher than most of the district that will be affected. As all of these requirements will not generally be met with in any particular case, a practical solution must be found that best meets the existing conditions.

The best method for the control of the flow in and out of the tank, should it be found desirable to attempt control to any degree, has not been given much consideration by water works engineers, in America at least. The elevated storage tank occupies somewhat the same relationship to the water distribution system as a storage battery does to an electric light and power system. A storage battery may be allowed to float on the lines, or the time for charge and discharge may be regulated, depending upon the purpose for which it has been provided. "Obviously, the size of the battery is greatly influenced by the character of the plant, prospects for increase of business, and probable character of the load increase. Also, the question of fuel and labor costs, combined with the above considerations, may make a great difference in the size of the equipment that will be productive of greatest economy."[6] A storage battery that is located near the center of a retail district of a large city, for the purpose of carrying the load for a few minutes, should there be an interruption of supply from the generating plant or sub-station, will be allowed to float with but little, if any, interference. But, should the storage battery be provided to absorb some of the output of the generating station during the period of light load, and to discharge during peak load, then controlling equipment must be installed as an adjunct to the station. "The advantage of the battery as a reservoir of energy, always floating on the station bus and ready for instant use in case of emergency, is the important

[5] JOURNAL, November, 1926.

[6] "Storage Battery Engineering," by Lamar Lyndon.

feature." Also "Under the conditions obtaining in some central lighting stations this method (peak load discharge) resulted, and will today result in a marked improvement in plant efficiency. . . ."[7] Elevated water tanks have been connected generally so as to float on the lines, and this method is best adapted for use in smaller cities, where the amount of storage that can be provided is sufficient to produce a full regulating effect, but in cities where the capacity of the tanks is not sufficient for this purpose, even though the pumps at the distributing station are given careful operation in an endeavor to correlate their use with the tanks, then it seems probable that the flow in and out of the tanks should be controlled.

DESIGN OF ELEVATED TANKS

To those who wish to acquaint themselves with the underlying principles of design of elevated tanks, reference must be made to text books on mechanics and design of framed structures. It is believed however, that reference should be made here to several items that are of prime importance, and about which those responsible for the construction and maintenance of tanks should have some information. The first of these relates to the settlement of foundations. The largest elevated tank that has been constructed is located at Charleston, S. C. This has been described by J. E. Gibson.[8] It has a capacity of 2 million gallons. Mr. Gibson states that "the settlement varied from $\frac{1}{4}$ up to 2.6 inches, depending upon the load and the location. The tests indicated that there would be some settlement of the concrete foundation, but the question was to properly distribute the load on this soil so as not to exceed $2\frac{1}{4}$ tons per square foot, including the live and dead loads and foundations." This is mentioned here to call attention to the fact that unless founded on rock or very dense and stable material, settlement to some degree will almost certainly occur; that after this settlement has taken place, unless it has proceeded uniformly, the stresses in the ank are bound to be different than would have obtained had no settlement taken place; and that when the foundations and structural members are proportioned, consideration must be given to the effect of settlement.

There is a difference of opinion among those engaged in tank

[7] "Manual of Storage Battery Practice," by Association of Edison Illuminating Companies.

[8] JOURNAL, September, 1927.

design, as to how much load will be carried on the foundation for the riser, and how much by the supporting columns, even without settlement. Wind pressures are always given consideration in design. It is suggested that until the effect of settlement is better understood, the foundations for the columns be designed to carry all the load, irrespective of the fact that part of the load will undoubtedly be carried by the riser. As the foundations are of prime importance, this item should be well controlled and a thorough study should be made of the soil conditions at the tank site. The type of foundations should then be determined, such as a continuous ring or individual footings under the columns, the allowable working stresses, and the material to be used must be specified.

It will be found that plate thicknesses will vary with different bidders. This difference is due, undoubtedly to different assumptions made by the designers. Since this condition obtains, it would be well for the purchaser to specify minimum thicknesses of plate based on conservative design. As unprotected steel will corrode, and as the amount of maintenance that will be given a tank will not be known when it is constructed, it is suggested that the thickness for bottom plates be made liberal and a minimum thickness stated in the specifications. In practice there will be found a difference in the diameter of the riser, as determined by different manufacturers. The riser must support a considerable load, and consequently its foundation must be adequate and the thickness of its plates must be sufficient to give it the necessary strength. It is therefore believed that the specifications should state the load that the riser and its foundations should be capable of supporting, together with the diameter and minimum thickness of shell. The appearance of a tank can generally be improved through the use of a riser having a diameter of generous size. In any particular installation it is further necessary to determine the elevation of the top of the tank, the elevation below which any storage that may be provided will not be included in computing the tank capacity, the form of roof and balcony, and the limiting stresses for the structural members. The use of an altitude valve is often desirable.

The experience with tanks as large or larger than 1 million gallon during the winter season in northern latitudes has been limited, because so few have been constructed, and consequently the trouble, if any, that will arise in these large tanks, through the formation of ice, is not well understood. Unless a tank is heated or protected, how-

ever, it should not be so operated that there will be but little flow in and out during severe freezing weather, for should the water which it contains remain at about the same level for a week or more, with air temperatures at zero or below, ice would form to a considerable thickness and trouble would likely ensue.

In determining the size of an elevated tank to use in any particular city, not only must the balancing effect on the system be considered, but also the storage of water for fire protection purposes, and the use of elevated storage for fire protection generally becomes of relatively greater importance as the size of the city decreases.

The following is submitted in conclusion:

a. Through the use of the elevated storage tank, a supply of water is made available for fire protection purposes. "The introduction of storage, either elevated and supplying the distribution system or for suction supply, offsets to a greater or less degree the need of duplication in various parts of a system, the value of the storage depending on its amount and location; . . ."[9]

b. The proper size and location for an elevated tank for any parricular city or town will depend upon local conditions. It should be placed in that area which is most in need of its beneficial effects, and that point is generally some distance removed from the pumping station.

c. The cost of a tank may only in part be justified by the estimated reduction in operating costs at the pumping station. This estimated saving in operating expense will probably be exceeded in practice, because of the failure of engine attendants to operate the pumps in the most advantageous manner, and because less changes in operating details are required when tank storage is available.

d. Through the use of an elevated tank a saving may be effected in expenditure for such capital cost items as pumps and mains, or the construction of such equipment and structures may be delayed for a time.

e. Trouble from water hammer is sometimes experienced when reciprocating pumps are used in a direct pressure system. The use of an elevated tank may reduce this operating difficulty.

f. Some of the standpipes that were erected some years ago and

[9] "Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defense and Physical Conditions," by National Board of Fire Underwriters.

which are located at or near the pumping station serve the purpose for which they were intended.

g. Careful consideration should be given the problem in an attempt to secure the best method for control and use of a tank. In smaller towns the tank should generally float on the lines. In large cities, because the amount of stored water is relatively less, some system of control should be adopted. For cities of moderate size, only through careful study can the method be found that will allow the tank to be used to the best advantage.

TREATMENT OF FILTERED WATER WITH LIME AT HARRISBURG, PA.

By Richard H. Gould[1]

The city of Harrisburg, Pa., is supplied with filtered water from the Susquehanna River. The filtration plant is of the rapid sand type built from designs of James H. Fuertes, Consulting Engineer, and has been in continuous operation since 1905. The filtered water has always been clear, pure and generally satisfactory. From time to time, however, there have been complaints as to "red water," particularly in the hot water systems and it has been known that service pipes and house plumbing had a relatively short life. The fact that no special corrective treatment was considered necessary up to within the last few years is an indication that the filtered water was not much more corrosive than in many other places. Some two or three years ago, however, Dr. Samuel F. Hassler, commissioner in charge of the waterworks, called upon us to study the problem of corrosion and make recommendations as to possible corrective measures. This was done and as a result the Harrisburg filtered water has received a treatment with lime for the past year and a half. In the course of this treatment a number of interesting observations were made, some of which are outlined in the following pages.

CHARACTER OF THE SUSQUEHANNA RIVER WATER

The Susquehanna River at Harrisburg has a watershed of over 24,000 square miles with considerably more than one million people resident thereon. The North Branch of the Susquehanna receives drainage from extensive anthracite coal mines and this flow follows usually along the east bank of the main stream at Harrisburg. The Juniata River, tributary above Harrisburg, carries a high alkalinity from the limestone region which it drains and flows mostly along the west bank of the main stream. The resulting water at Harrisburg is one of widely varying characteristics and subject to rapid changes in chemical and physical properties dependent largely on rainfall

[1] With James H. Fuertes, Consulting Engineer, New York, N. Y.

fluctuations on different parts of the drainage area. The waterworks intake is located on an island in the middle of the river, the site being so selected as to secure the best average water. A disproportionately heavy rainfall in the coal mining regions will, however, force water with acid mine wastes and with black coal particles in suspension over to the intake. A flood in the Juniata River will reverse the situation so that the water to be treated will then have a high, fine, yellow turbidity accompanied by a high alkalinity. All sorts of intermediate combinations are possible. In reference to the question of corrosion it should be borne in mind that at one time or another nearly any combination of chemical constituents usual in a potable water may be present.

GENERAL FEATURES OF WATERWORKS

Recent extensions have increased the capacity of the filter plant to about 20 m.g.d., but the average draft is now only about 12 m.g.d. Raw water can be pumped to one or both of two settling basins and flows thence to coagulating basins. Both settling basins may be operated in series or in parallel either with or without the use of a coagulant. Under ordinary high turbidities the basins are operated in series, the first basin being used for plain settling. Double coagulation is practiced, the dose being split between the second settling basin and the coagulating basin. For light turbidities the entire dose goes to the coagulating basins. Alum is used as a coagulant. The adaptability of the water to this treatment and the efficiency of the process is indicated by the fact that the average yearly amount of alum used is only about one half grain of alum per gallon of water treated. Lime is used to assist the alum reactions only when the natural alkalinity is deficient. From the coagulating basins the water is passed through rapid sand filters of the usual type and collected in a clear well under the filters.

As an index of the extent of the corrosive action of the filtered water the condition of the wrought iron underdrains of the old filters may be of interest. The underdrains in question are the original example of the perforated pipe system, developed by Mr. Fuertes and now in such general use, and are of genuine wrought iron. They were inspected after having been in service for twenty years when the recent extensions were made. Their condition at that time was good enough so that they were not replaced. At the present time

the underdrains in some of the old filters are being replaced after a service of twenty-three years.

From the clear water well the water flows through a 42-inch pipe under the river to the suction well of the pumping station. The suction well is large having been used as a grit chamber in the days before the filter plant was built. Over 90 per cent of the water is used in the low service district and this is pumped to a low service reservoir of about 20 million gallon capacity. From here it flows to the distribution system. It takes from two to three days for water to flow through this reservoir and the distribution system back to the tap at the laboratory. This should be kept in mind in comparing the results of the analyses of the filtered and tap waters.

LIME TREATMENT ADOPTED

The necessity of some treatment to lessen the corrosive qualities of the Harrisburg water was apparent. The use of sodium silicate and sodium carbonate was considered, but the treatment of the filtered water with lime was selected as being most practicable. Its cost was much less than the other methods and arrangements were such that existing dry feed lime machines could be used with simple additional works to permit its application to the filtered water. The addition of lime before filtration in quantities sufficient to correct the corrosive properties was found to interfere seriously with the proper coagulation. This is in accord with experiences elsewhere and with accepted theories of coagulation. It was considered essential to add the lime after filtration, but it was thought best to keep as much as possible of the lime sludge out of the distribution system.

The best point of application was found to be at a manhole at the junction of two pipes leading from filtered water wells where good mixing would occur and before the water passed under the river to the pumping station. A 6-inch cast iron pipe from the existing lime machines in the head house was laid on a substantial down grade to this point of application. Near the upper end of the line two solution tanks were constructed to which the lime suspension coming from the lime machines is passed. The tanks are deep and of small sectional area giving a long vertical rise for the lime particles in passing through. They have a detention period of something over an hour at flows of 50 per cent over that necessary to dissolve the usual lime dose. As a matter of practice more water than the above

is used for solution purposes. The detention period is therefore somewhat lessened and the liquid passing off is not a true solution, but has a fine lime flock in suspension. The heavier insoluble particles are, however, separated out. They are periodically flushed by gravity and with the aid of special washing arrangements to the plant sewer. The tanks are cleaned every three to four weeks and have given no trouble. But little effective lime passes off with the sludge. Should any lime sludge pass through the tanks it would be held back in the suction well of the pumping station.

EXTENT OF TREATMENT

The free CO_2 in the Harrisburg filtered water ranges from 2 to 10 p.p.m., averaging about 5 p.p.m. The lime necessary to remove this amount would ordinarily not be expected to increase the hardness of the water more than about 10 per cent. The natural alkalinity of the water is often low, most of the hardness being of the incrustant or sulphate type. The plan at the start of the lime treatment was to add sufficient lime to remove all the free CO_2 and to produce a trace of normal carbonates, but not to add enough to bring about a caustic alkalinity. The low natural alkalinity of the water makes it impossible at most times to bring about a precipitation of $CaCO_3$ and this was not desired. It was thought, however, that the maintaining of a few parts per million of normal carbonates would permit the formation of a protective coating on the pipes at those places where corrosion was taking place. This was based on the assumption that the ferrous hydrate formed by iron going into solution would react with the carbonates causing their deposition with the rust. In the absence of free CO_2 this film would not again be redissolved. This phenomenon is partly explained by Speller in the Journal of the New England Water Works Association, March, 1925. This may or may not be the correct explanation of the action taking place, but the treatment to the extent indicated has brought about the anticipated results in the reduction of corrosion. A drop of acid added to plates hung for about three months in the water before and after treatment indicates qualitatively that there is more carbonate deposited on the plate hung in the treated water.

CONTROL OF LIME DOSAGE

The amount of lime to be added each day is determined by the amount of free CO_2 in the filtered water and by the amount of water

treated. The nominal dose has been at different times 8, 9, and 10 pounds of lime per million gallons for each p.p.m. of free CO_2 present. The lime used was hydrated, being about 88 per cent $Ca(OH)_2$. pH values of the filtered and tap water were recorded but were not used in the control of the dosage. As can be seen from figures 1 and 2 the resulting pH values of the treated water under the different rates of lime application were fairly uniform. These values were considered quite incidental and no effort was made to maintain a predetermined figure. The variations of the pH values of the filtered water would indicate that it would be difficult to control the lime application by means of these figures.

MEASURE OF CORROSION

The preliminary investigations brought out the fact that there was a large drop of dissolved oxygen in the water as it passed through the distribution system. Presumably the oxygen lost was going into the corrosion of the iron piping. There was no biological growth to otherwise account for the results. Observations of the amount of red water at dead ends and complaints of the consumers while important are at best unsatisfactory as a quantitative measure of any improvement that might be brought about. The drop in the dissolved oxygen in passing through the system was thus considered the best measure of the corrosion taking place. In order to establish the nature of conditions before treatment started dissolved oxygen and other analyses were taken at the extreme north and south sides of the city and at the filter plant which draws water from the center of the city.

RESULTS SECURED

The results secured in the first 16 months of the operation of the lime treatment have been definite and generally satisfactory. There has been a noticeable decrease in the number of complaints of red water troubles. There has been no appreciable effect in steam boilers using the water. At least no complaints have been received for this cause from consumers who were aware of the changed conditions. The degree of protection afforded the piping system is shown graphically in figure 1. This figure shows the drop in dissolved oxygen of the water in passing through the system at different stages of the treatment. For the two months preceding the treatment the

drop in dissolved oxygen was about 4.45 p.p.m. This drop decreased rapidly after the first few days of treatment and has continued at a lessening rate until at the present time it is about 0.2 p.p.m. or less than 5 per cent of that formerly taking place. Continuous treatment was in force, however, for over a year before this degree of protection was secured.

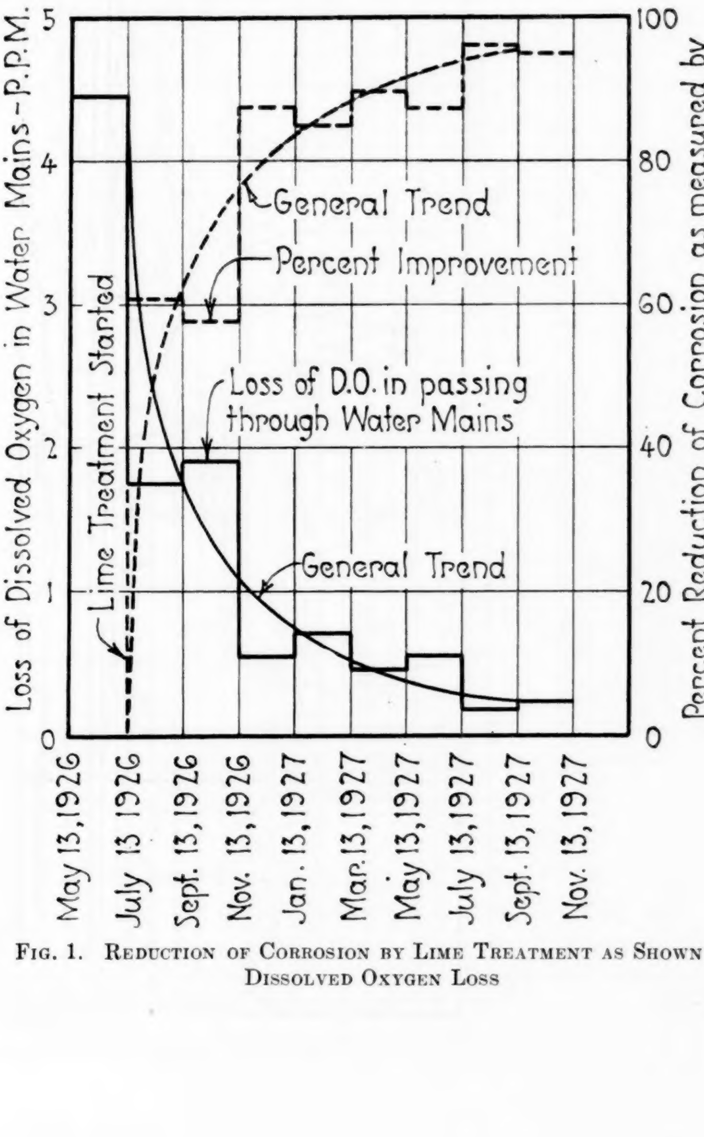
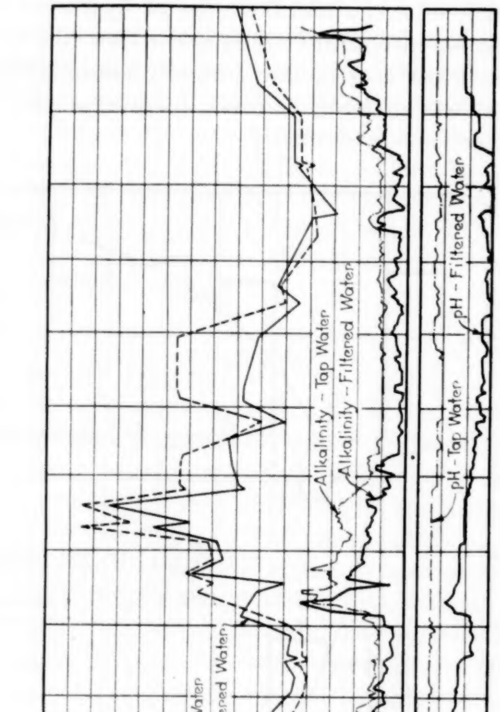


FIG. 1. REDUCTION OF CORROSION BY LIME TREATMENT AS SHOWN BY DISSOLVED OXYGEN LOSS


Alkalinity & Hardness - P.P.M.
150
100
50
0
pH
9
8
7
6
Lime Treatment
Hardness - Tap Water
Hardness - Filtered Water
Alkalinity - Tap Water
Alkalinity - Filtered Water
pH - Tap Water
pH - Filtered Water

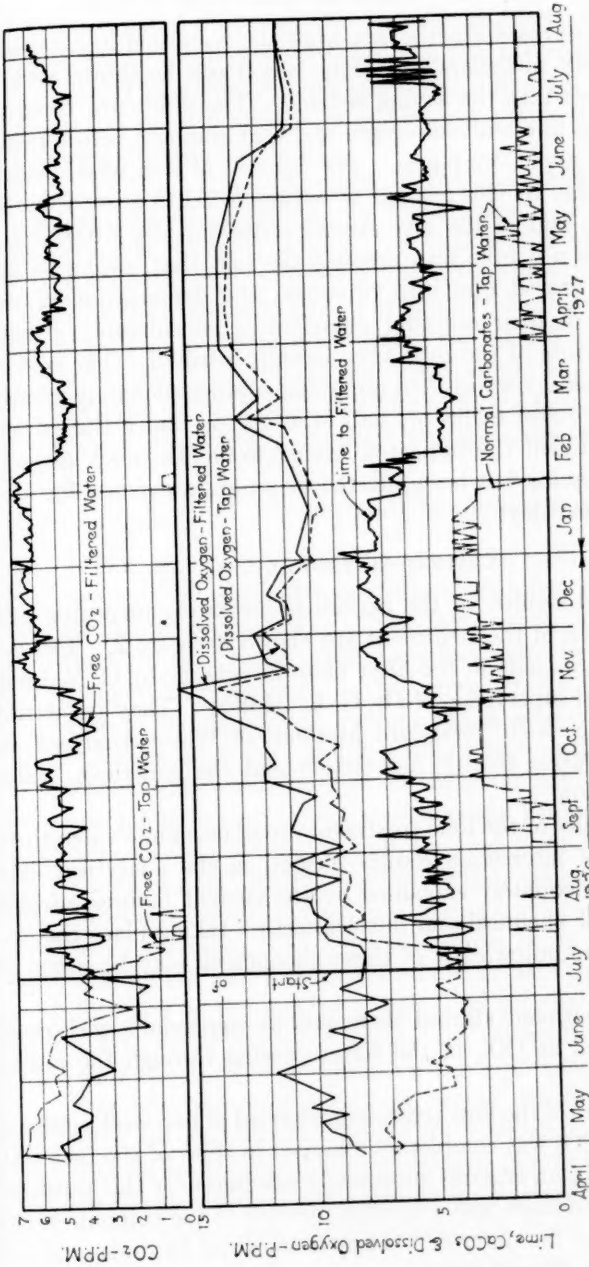


FIG. 2. ANALYTICAL DATA ON LIME TREATMENT OF FILTERED WATER, HARRISBURG, PA.

ECONOMIC VALUE OF TREATMENT

It is difficult to state exactly just what the reduction in corrosion means to the city in dollars and cents, but it can be shown by approximate figures that the saving is large. The difference between the present drop in dissolved oxygen and that common before treatment started is about 4.2 p.p.m. The amount of iron which would be rusted each day by this amount of oxygen is worth at its value as iron water pipe laid in the city streets approximately $100.00 per day. This does not take into account the fact that, owing to the bulking of the rusted iron into tubercles, the depreciation of the pipes in terms of their carrying capacities is considerably greater than the proportion of the total iron actually affected. The cost of the individual house services and plumbing is proportionately greater than that of the street mains per unit of weight so that if the private piping were included the indicated saving would be much greater. This apparent saving has been effected at an extra expense for lime of about $3.00 per day.

ANALYTICAL RESULTS

The analytical results for the periods immediately preceding and for twelve months of the treatment are shown in figure 2. The determinations were made in the filter plant laboratory by G. N. Book under the general supervision of Dr. G. R. Moffitt. They are carried out in accordance with "Standard Methods of Water Analyses" of the American Public Health Association and the American Water Works Association.

While the results of the lime treatment are of economic value there are a number of interesting results secured in the analytical data which are not adequately explained by the current theories of pipe corrosion and the chemical and physical action taking place therein. Some of the more noteworthy of these phenomena may be summarized as follows:

(1) Before treatment started there was an appreciable pick up in acidity, expressed as CO_2, in the water passing through the piping system.

(2) At the start of the lime treatment a period of two weeks elapsed before the free CO_2 was completely removed in spite of the fact that lime was added in an amount supposedly adequate for this purpose. During this period there was a marked increase in the sulphate hardness (used here as the difference between the total hardness and the alkalinity) of the filtered water.

(3) For six of the twelve months considered the hardness of the lime treated water was less than the hardness of the untreated water and this reduction was largely in the non-carbonate hardness.

(4) For certain periods there were abnormal increases in hardness in the treated water. Here also the major fluctuation was in the non-carbonate hardness.

(5) The average hardness of the tap water for a twelve-month period exceeded that of the filtered water by an amount that corresponds within 0.1 p.p.m. of that which would theoretically be produced by the amount of lime added during the same period.

(6) For the same period of twelve months the average alkalinity of the tap water exceeded that of the filtered water by a figure agreeing within 0.5 p.p.m. of that which would be caused by the reaction with the free CO_2 present with the lime added, taking due consideration of the normal carbonates present in the tap water.

MORE KNOWLEDGE NEEDED

The data before us are not complete enough to be entirely satisfactory. The absence of definite analyses for hardness at certain periods is disappointing. The fact that it takes from two to three days for the filtered water to reappear in the tap sample is another element of uncertainty. The general trends, however, are too positive to be ignored and warrant careful study.

Baylis (JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION, June, 1926) has discussed the importance of negative ions, such as the sulphate ions, in pipe corrosion and has suggested that these ions may be concentrated against the pipe walls by the products of corrosion of iron. In the Harrisburg data there is evidence that similar substances are behaving in a manner not easily explainable by the usual theories. Are these substances being at times drawn to the sides of the pipe and separated out or held there for a time and later returned to the flowing stream? If so what, if any, reactions are taking place and what causes the reversal of the movement? Do we have in the film adjoining the pipe anaerobic conditions where the reduction of sulphates can occur? If these changes in the hardness are related to corrosion the Harrisburg results would indicate that it is a type of corrosion not calling for oxygen for its completion as the changes are not reflected in the dissolved oxygen figures.

The phenomena outlined under (2) at the start of the treatment, where the lime did not at once appear effective, might indicate that

there was at that time a concentration of material along the pipe walls, possibly including such substances as magnesium sulphate, bringing about reactance with the lime added, retaining the hydrate as a precipitate on the pipe walls and releasing soluble sulphates to the flowing water.

FLUCTUATIONS IN HARDNESS

One of the most puzzling features of the analytical results is the fluctuation between the hardness of the filtered water and the lime treated water. Because of the uncertainty of the exact time of passage of the water through the distribution system at different times and the limited number of hardness analyses too much weight can not be given to the results of any one day. General trends as indicated by a number of individual results are more reliable. For twenty-five days on which the hardness of the tap water was less than that anticipated from the amount of lime added to the filtered water it was found that the total hardness averaged 10.7 p.p.m. less than anticipated while the alkalinity averaged only 1.3 p.p.m. less. For twenty days on which the tap water had a hardness greater than that expected the total hardness of the tap water exceeded that computed from the amount of lime added to the filtered water by an average of 14.8 p.p.m. The figure for the alkalinity, however, was only 0.6 p.p.m. above that computed. The soap method of hardness analysis is known to be inexact, but it is not thought to be sufficiently inaccurate to account for the fluctuations noted. Fluctuations on certain days were of course greater than the averages given. The unaccountable fluctuations appear from the above to be chiefly in the non-carbonate hardness, but the causes controlling the direction and magnitude of the fluctuations seem to be obscure.

CONCLUSIONS

This paper has given a brief account of certain definite and valuable results secured in the reduction of the corrosive properties of the Harrisburg water. It seems to have been easier to produce the results desired than to develop information as to exactly what is taking place within the distribution system in question. Perhaps this latter phase is of secondary importance, but it is nevertheless for this last reason that this paper is written. It is hoped that further light will be shed on some of the uncertainties outlined herein.

DISCUSSION

Carl A. Hechmer:[2] Mr. Gould's experiences at Harrisburg are, in many instances, similar to those met with by the writer in the operation of the water filtration plants in the Washington Suburban Sanitary District, Maryland, particularly at Hyattsville. This plant obtains its supply from the Northwest Branch of the Anacostia River, a decidedly flashy stream with turbidities varying from 5 to 5000 p.p.m. and a corresponding variation in chemical and physical properties.

The Hyattsville purification works were put into operation in 1920, but lime treatment after filtration was not introduced until 1923. Until March 1927, alum alone was used for coagulation, soda ash being used only on high turbidities to make up the deficiency in natural alkalinity and to effect complete precipitation of the alum. Since the above-mentioned date, liquid sodium-aluminate has been used with alum for coagulation, materially reducing the required alum and lime doses and eliminating the use of soda ash altogether.[3]

The writer has also made numerous experiments with lime before filtration in an effort to reduce the dose of lime afterwards and maintain a passive tap water. As at Harrisburg, the floc formation was seriously interfered with, and we abandoned the procedure.

When lime treatment was first introduced in our plants, pH control was used entirely. We found that, if a pH value of from 7.2 to 7.4 was maintained in the tap water, corrosion was materially reduced and few red water complaints were received. Our greatest difficulty was in maintaining this pH value in the water after it entered the distribution system. Although lime was being added to bring the pH value of the filtered water to 7.4, the water on the far ends of the distribution system was often found as low as 6.6 and 6.8. The lime dose was then controlled for about a year by the monocarbonate alkalinity test, using phenolphthalein as an indicator, the pH readings being kept for record purposes only. By adding enough lime to the filtered water to give a trace of pink color in the presence of the indicator, the pH value was kept at about 8.0. To avoid a

[2] Department Engineer, Washington Suburban Sanitary District, Hyattsville, Md.

[3] "Coagulation Studies at Washington Suburban Sanitary District," by Morse, Hechmer and Powell, Industrial and Engineering Chemistry, 20: 1, p. 56.

caustic water, the samples were titrated with H_2SO_4, giving an indication of the intensity of the color and a guide for the operators by which to govern the lime dose. The drop in pH value was still very noticeable in the distribution system, but with a very high initial pH value it was possible to maintain a value of 7.0 to 7.2 at the most distant points.

The drop in pH value after leaving the plant was found to be caused by the after-precipitation of the lime with small quantities of alumina which were passing through the filters. Efforts to reduce the alum dose or to complete the reaction in the coagulating basin by the addition of soda ash or lime, or various combinations of both, resulted in poor filter effluents. Since starting the use of sodium-aluminate, the average alum dose has been reduced from 1.25 to 0.55 grains per gallon. The passage of alumina through the filters has been eliminated and there is very little reduction in the pH value of the water after it enters the mains. The method of pH control is again being used entirely in adjusting the lime dose, with excellent results. The average lime dose has been reduced from 0.88 to 0.30 grain per gallon and we maintain a pH value of 7.4 in the water leaving the plant. During the present winter only a few red water complaints have been received and we believe the water being supplied in the Sanitary District to be non-aggressive.

John R. Baylis:[4] This excellent paper gives the most specific information yet published on what can be accomplished in reducing corrosion by treating the water with lime. The loss of dissolved oxygen in the water of a closed system such as the distribution system of a water works is a fairly good measure of the amount of corrosion taking place. To reduce the loss of dissolved oxygen by the amount shown by Mr. Gould is remarkable, yet it is in accordance with what was found at Baltimore. There was no measure of the loss of dissolved oxygen at Baltimore before the treatment was started, consequently the reduction cannot be stated, but there is very little loss now, which is in accordance with what is found at Harrisburg.

In a recent paper[5] the writer stated that the ideal chemical balance for a water was for it to be saturated with calcium carbonate. The saturation point of calcium carbonate depends on the pH and the

[4] Department of Public Works, Chicago, Ill.

[5] Baylis, John R. Treatment of Water of Water to Prevent Corrosion. Industrial and Engineering Chemistry, 19: 777, July 1927.

calcium carbonate in solution. The following table gives the saturation equilibrium at 23°C. when distilled water is used:

Saturation equilibrium of calcium carbonate

ALKALINITY	pH
15	9.3
20	8.9
25	8.7
30	8.5
40	8.1+
50	8.0+
70	7.8
100	7.6
120	7.5
140	7.4
190	7.2

Most natural waters contain some magnesium carbonate and this may give it a slightly different equilibrium. To illustrate, the equilibrium of the Lake Michigan water, which contains approximately 10 parts per million of magnesium, requires a pH of about 7.9 for an alkalinity of 118. If no magnesium were present the pH for this alkalinity, providing all the alkalinity was calcium carbonate, would be 7.5. Certain neutral salts such as the sulfates and chlorides also influence the equilibrium slightly.

It is an easy matter to find the saturation equilibrium of a given water by adding caustic lime to produce what is thought to be the approximate equilibrium, then add powdered calcium carbonate. Allow the solution to stand in a closed pyrex or other non-corrosive glass container for two or three days with frequent agitation. The pH and alkalinity should be tested both before and after the calcium carbonate powder is added. If there is practically no change in the pH and alkalinity after standing several days it is at equilibrium and this gives the equilibrium at approximately the alkalinity established after the lime treatment. Adding powdered calcium carbonate to water containing considerable CO_2, it will produce a greater alkalinity than if the CO_2 is first largely neutralized with caustic lime. There is no need for throwing away the calcium carbonate powder if other tests are to be made. In fact the powder should be washed thoroughly with the water to be used before adding to the solution to be tested.

Mr. Gould has given a very clear account of what has been accomplished at Harrisburg. There is nothing in the discussion contrary to the writer's experience. It is a practical demonstration of what can be done at most any city where the water is corrosive. That it is economy to treat corrosive waters has been proven so conclusively that it is a wonder the treatment is not universally adopted. The convincing data given by the author will do much towards promoting interest in treating corrosive waters.

Robert Spurr Weston:[6] It is pleasant to add what one can to Mr. Gould's excellent account of the experiments at Harrisburg. The writer only regrets that he can throw so little additional light upon the parts of the work which have baffled the author to explain. Fortunately, lack of explanation and unformed theories have not prevented good results in practice.

The devices used to add the calcium hydrate seem excellent and apparently avoid the danger of adding insoluble matter with the active chemical. For neutralizing waters the writer has used successfully a quick lime made from the Vermont marble. This contains a minimal amount of insoluble matter.

While the adding of calcium hydrate at the beginning of a considerably long period of coagulation will certainly interfere with flocculation, as the author has observed, it has been added to coagulated water as it enters the filters without appreciably re-dissolving the flocs. In these cases, apparently, the flocs already formed resist the solvent action of the alkali during the few minutes required for the treated water to pass from the filter inlet where the lime is added to the point in the filter bed where the flocculated suspended matter is removed.

Regarding the necessity for adding alkali enough to remove all of the carbon dioxide and to insure the presence of normal carbonates in small amounts, the writer is in doubt. While conditions in Harrisburg may demand this degree of treatment, the writer's experience elsewhere would cause him to reduce the dose of lime, after the protective coating had once been formed upon the insides of the pipes, until about 0.5 p.p.m. of carbon dioxide remained in the tap water delivered to consumers. The formation of chalky accumulations in mains, curb cocks and services is to be feared, particularly as the term of treatment lengthens with the years.

There is a decided "lag" in the effect of treatment. In some of the

[6] Consulting Engineer, Boston, Mass.

cases under the writer's observation this effect has been more marked than in the case at Harrisburg. Probably this lag is more evident where the concentrations of dissolved mineral matter are lower, as in the case of softer waters. While it lies in the field of speculation and may be stated with reservations, only one hypothesis may be advanced to explain this action.

In such dilute solutions as water all reactions are appreciably accelerated by contact, particularly by contact with the product of previous similar reactions. Mass action is also a factor. Consequently, coatings already formed help to flocculate and precipitate in the water the products of reaction which, but for contact action and concomitant surface absorption, would remain in colloidal suspension for a much longer period and delay indefinitely the formation of protective coatings.

The writer can but agree with Mr. Gould that the coating is but a stage in the reaction and its function is that of a reservoir which absorbs and releases ions with variations in solution pressure, just as a hydraulic reservoir gives and takes with changes in inflow and consumption respectively.

The protective action of sodium silicate, which is coming into use to counteract corrosion, is analagous and illustrates the theory. When this chemical is decomposed a silica gel is formed which clings to the pipe and protests. This gel slowly dehydrates and in its dehydrated state it is poor protection because it crumbles so readily and disappears. Consequently the gel phase of coating must be maintained by frequent or continuous additions of chemical. It requires time to form the coating; the coating remains for a considerable time after the application of the chemical has been stopped.

At Harrisburg the writer would be impelled to apply silicate of soda at least occasionally, perhaps alternating its use with that to lime. The compound of lime and silicate thus formed on the pipes seems to be more durable than that formed by the addition of either chemical alone. Furthermore, the use of silicate avoids increases of hardness and the necessity for removing the carbon dioxide from the water.

STEEL TANK CONSTRUCTION[1]

By I. E. Flaa[2]

In the earliest records of civilization we find that supplying water to communities was one of the great engineering problems. In King Solomon's time extensive reservoirs in the form of pools were constructed for that purpose. It was during that time, also, we learn from the Bible, that the first artificers of metals were mentioned.

It is a long jump from those ancient times to the present and the supplying of water and the working of metals are still the great and important engineering problems.

Tanks in some form or other are used in both hilly and flat communities. In the flat communities they are generally elevated upon steel or concrete towers of sufficient height to give the desired water pressure, while in the hilly communities they are generally placed upon some hill and supply a certain area around the hill which could not be supplied from larger distributing reservoirs.

When the communities begin to build higher and higher up to hillsides, as in San Francisco, more regulating tanks have to be built to supply their needs. At present in San Francisco there are 14 tanks, besides the 7 distributing reservoirs to properly regulate the pressure in the various pressure zones throughout the city.

Four of the tanks are of steel or iron, one of reinforced concrete, and the remainder are wood. The four steel tanks are listed below:

	BUILT	DIAMETER	DEPTH	CAPACITY
		feet	*feet*	*gallons*
Clay Street	1886	60	11	235,000
Clarendon Heights Tank	1895	80	15	500,000
Presidio Heights Tank	1902	60	36	700,000
Forest Hill Tank	1927	45	25	300,000

The first three tanks were built with steel bottoms fastened rigidly to the shell and rest on concrete bases. All are in good condition and

[1] Presented before the California Section meeting, October 7, 1927.

[2] Office Engineer, Spring Valley Water Company, San Francisco, Calif.

in operation at the present time. These tanks are painted on the outside every four or five years with natural color graphite paint.

Forest Hill tank was built this year to take the place of a smaller wood tank that had become inadequate.

The first problem was to obtain the site, and then permission from the Zoning Commission to build it, which permission was obtained after we promised to make it ornamental in design and to plant trees and shrubs around, after erection, to make it still more pleasing to the aesthetic eye.

The design of this tank was influenced largely by the fact that the Company had on hand sufficient plates, rivets, and material to build a 45 foot diameter by 40 foot high tank. These plates had been stored for twenty years in the Company's warehouse at Millbrae. They were intended for a tank whose construction was to have started April 18, 1906, the day of the San Francisco earthquake and fire.

Instead of building a tank 40 feet high it was decided to use the material for two 25-foot tanks, one to be built immediately, and the other, when needed, could be made up from the remaining plates using top and bottom plates of the original tank to make up the necessary side courses. The tank is constructed as a round cylinder resting on a concrete base in such a manner that the cylindrical shell is free to move within certain limits on the concrete base. There were three reasons for this: (1) in event of another earthquake there will be less chance of the lower seams becoming ruptured; (2) to take care of expansion and contraction when the tank is empty which might stress the joints, causing leaks; (3) it is a known fact that the bottom of the tank will deteriorate before the shell.

The concrete base 12 inches thick is reinforced top and bottom with $\frac{1}{2}$ inch square bars both ways at 18 inch centers; the outer edge of the slab for 3 feet was made about 18 inches thick principally to insure a good foundation under the place of greatest load. A water tight joint between shell and base was obtained by constructing a depression made in the concrete in which was imbedded an 8 by 6 by $\frac{7}{16}$ inch angle on which rested the angle riveted on to the bottom of the shell. The inside of the depression was first caulked with oakum and then filled with an asphalt filler known by the trade name of "Biturine Joint Mastic." The outside of the depression was also filled with the same material to keep the water from coming in contact with the two angles, where they join, and cause rusting. A full load test proved that the joint was absolutely tight. This joint is shown in figure 1.

During the excavation for the base a layer of loose sand was encountered which sloped down hill and intersected the base excavation on approximately the middle of the foundation. In order to avoid the possibility of this loose sand flowing from under the foundation it was all removed and replaced with solid concrete of a lean mix, thus in effect one-half of the base is resting on solid rock and one-half on concrete.

Utmost care was taken in mixing the concrete for the base slab to make it dense and watertight. The mix was designed to give a

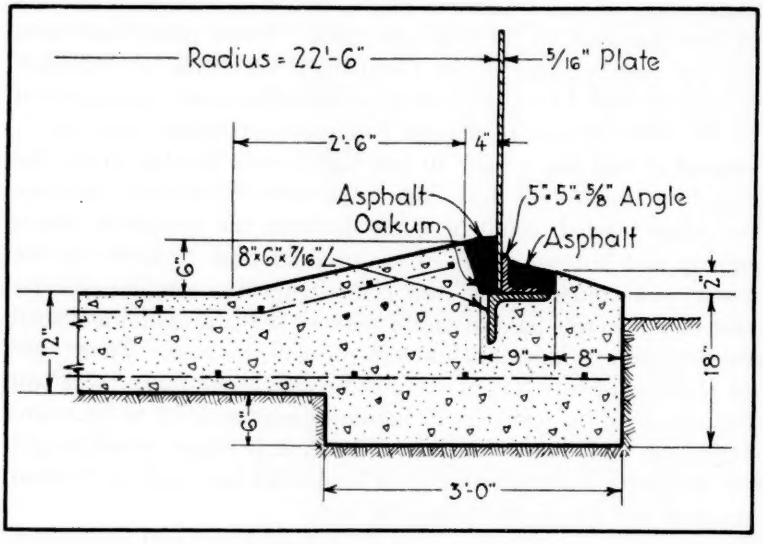


Fig. 1. Detail of Joint

minimum of 2000 pounds per square inch concrete and tests taken show an average of about 2300 pounds per square inch was obtained.

The conical roof is of wood frame and sheeting covered with variegated colored asbestos shingles, and is supported by five 8-inch I beam columns which rest in concrete bases cast on the bottom slab. These columns are free to move on their base. The columns are braced to the side of the steel shell. The roof is ornamented with a galvanized iron cornice, which is also a ventilator, and is surmounted with an ornamental galvanized ventilator in the center.

The steel plates forming the shell are $\frac{5}{16}$ inch thick. The vertical

joints are double-riveted lap joints and the round-about joints are single-riveted lap. On the bottom was riveted a 5 by 5 by $\frac{5}{8}$ inch angle while on the top 2 to 5 by 5 by $\frac{5}{8}$ inch angles were riveted, upon which wood sills to support the roof rafters were bolted.

The plates were painted with one coat of red lead, after they had been rolled and punched and before they were delivered at the site. After erection another coat of red lead was placed both on the inside and outside. The outside was then given a green finishing coat. This protection was deemed advisable as the site is subjected to very severe ocean fogs during the greater part of the year.

The excavation for the foundation was let by contract.

TABLE 1

Cost of Forest Hill tank

Grading and excavation		$1,394.46
Concrete foundation		3,012.80
Construction and erection:		
Plates, beams, bars and rivets	$2,171.99	
Cleaning and shipping plates	382.03	
Fabricating and erecting tank (contract)	2,680.00	
Biturine joint mastic	263.62	
Miscellaneous	134.91	5,632.55
Roof cornice work, etc. (contract)		2,588.00
Engineering		767.20
Miscellaneous		20.00
Total		$13,415.01*

* Or about $44,717 per million gallons storage.

The concrete foundation was built on a cost plus basis.

The fabrication and erection of the steel work was let by contract to the Western Pipe and Steel Company, while the roof was built by another contractor.

The tank was completed and ready for use ninety days after the first contract was let.

The cost of completing the work is shown in table 1.

A steel tank 95 feet in diameter and 30 feet high with a capacity of 1,500,000 gallons has just been erected by the Marin Municipal Water District at a point on the Tiburon Peninsula opposite Belvedere Island. Plans and specifications were prepared by J. S. Peters,

Engineer for the District, and bids called for the fabrication and erection of the tank. Eight bids were received ranging from $26,948 to $18,575. The lowest bid of $18,575 by the Chicago Bridge and Iron Works was accepted.

Delivery was made within sixty days after the contract was let and the erection took about six weeks more.

The tank is constructed of steel plates ranging from $\frac{5}{8}$ inch thickness for the bottom course to $\frac{1}{4}$ inch for the top course. The vertical joints for the three lower courses were double butt strap riveted, the upper two courses triple riveted and double-riveted lap joints, these riveted joints being designed for the working pressure of the tank. With the usual safety factor and joint efficiency the round-about joints are single-riveted lap spaced 4.81 inches for lower course to 2.51 for the upper course. This rivet spacing seems rather great as compared with our usual western practice, but their only function besides supporting the weight of the courses above is to make the tank water tight and the full load test proved that this result was obtained. The rule for spacing the round-about rivets is that the spacing of rivets for these joints shall not be more than 10 times the thickness of the thinnest plate. In the design for this tank somewhat less than 10 times the thickness was used.

The bottom is of $\frac{3}{8}$ inch steel with riveted joints fastened rigidly to the shell and the top is of No. 10 gauge welded steel, supported by channel columns.

The tank rests upon a foundation specially prepared by the Water District. The site was excavated down to the proper grade, then a layer of clay of a minimum of 3 inch thick and a 5 inch crown at center was wet and rolled; on top of this was placed a 2 inch layer of No. 4 rock; this layer was then thoroughly sprayed with No. 2 road oil on which was placed rock dust or screenings. This was then rolled to a hard finish. Over this was placed about 2 inch of sand on which the tank rests, the bottom being first painted with Bitumastic Enamel before lowering on the sand.

Drains at the toe of cut lead away all water from the adjoining hillside, keeping the foundation dry. All the inside of the tank was painted with the same material and the outside sprayed with two coats of Gelinite and Graphite mixed, and finished with one coat of green paint.

To reach the tank the Water District built about 4000 feet of road. The cost data are shown in table 2. Thus you can see by comparing

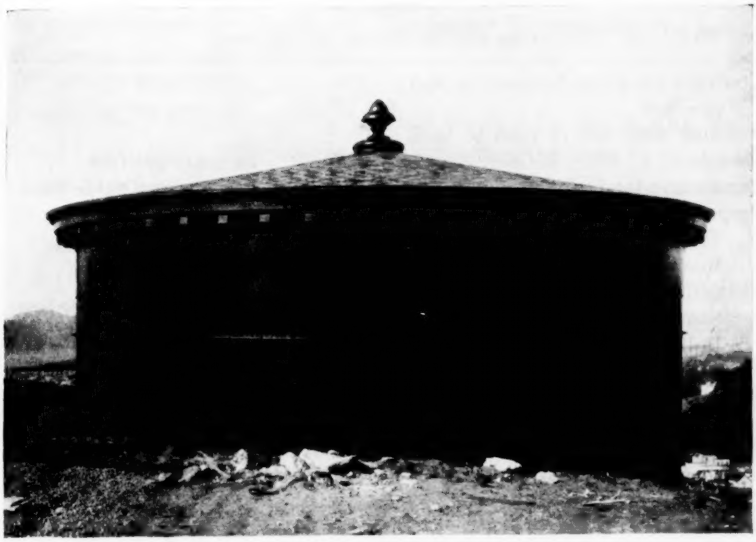


Fig. 2. Completed Forest Hill Tank

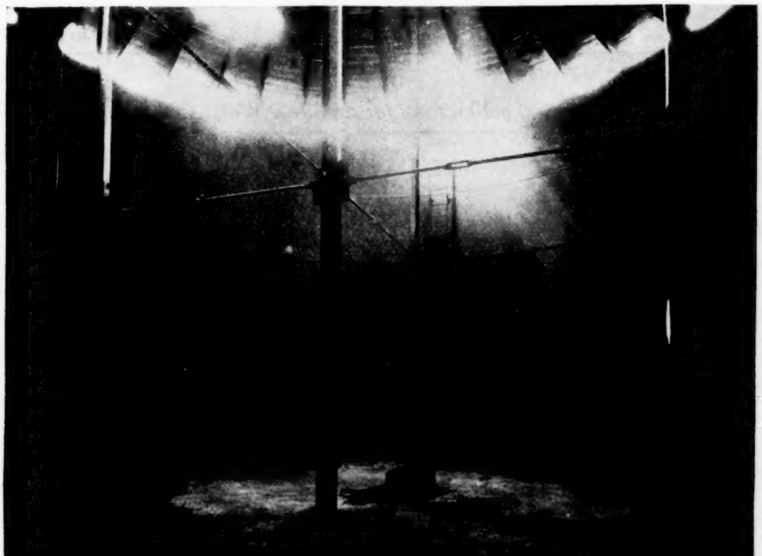


Fig. 3. Interior of Forest Hill Tank Showing Roof Columns and Interior Bracing

TABLE 2

Cost data on Marin District tank

	Cost	Approximate unit prices
Contract price for fabrication and erection	$18,575.00	1¼ cents per gallon
Building 4028 feet of road to tank site	2,174.00	54 cents per foot
Excavation for tank foundation	2,777.00	94 cents per cubic yard
Preparing foundation:		
Tractor and grader $50.00		
Rock and screenings 228.00		
Oil 171.00	856.00	11 cents per square foot
Sand 78.00		
Rolling 189.00		
Equipment 140.00		
Painting inside of tank and outside of bottom—bitumastic enamel	2,530.00	11 cents per square foot
Painting outside of tank, inside of roof and structural steel	980.00	3½ cents per square foot
	$27,892.00	= $18,595 per million gallons
Valves and piping	1,281.00	
General	131.00	
Total	$29,304.00	= $19,563 per million gallons

TABLE 3

Cost of 300,000 gallon tank for San Jose Water Company

Excavation 400 yards	@ $1.00		$400.00
65 yards gravel	@ 2.50	$162.50	
100 barrels cement	@ 2.60	260.00	
3060 pounds steel	@ .04	122.40	
Labor on steel	@ .02	61.20	
Labor mixing and pouring	@ 2.00	130.00	
Miscellaneous		100.00	
		836.10	
Contractors' profit	@ 10 per cent	83.61	
		919.71	919.71
Steel shell and roof (contract)			3,700.00
Cartage on steel shell 25 tons @ $1.00			25.00
Painting tank			300.00
			5,344.71
Miscellaneous			155.29
			$5,500.00*

* $16,500 per millon gallons.

the costs of these two tanks, that the larger the capacity the less the cost per million gallons storage.

The San Jose Water Company has recently erected a steel tank of the same size and capacity as that erected by the Spring Valley Water Company. The thickness of plates ranging from $\frac{5}{16}$ to $\frac{3}{16}$ inch. All joints are lap joints and each course fitting into the course below like a slip-joint pipe.

The bottom was of reinforced concrete of the same design as that of the Spring Valley Water Company except that there was no angle iron imbedded in the concrete, and the roof is conical and made of steel plates.

This Company also erected two 50,000 gallon steel tanks at a contract price for fabrication and erection of $1423 each. Both these tanks are 22 feet in diameter and 18 feet high and have steel bottoms and tops. They are set on reinforced concrete, 8 inches thick, on which was placed 2 inches of sand which was saturated with road oil. The cost figures are shown in table 3.

DIESEL ENGINE DRIVEN PUMPS[1]

By Rodney D. Hall[2]

The Diesel engine as a prime mover, due to its exceptionally high fuel economy, naturally suggests itself for use in water works installations.

In the operation of oil pipe lines advantage was taken of the Diesel engine for driving reciprocating power pumps as early as 1913. This type of prime mover is now practically the standard for new installations in this most extensive industry.

The water works field therefore has the great advantage of the long and wide experience of the pipe line companies in the use of Diesel engine driven pumping units of all the standard makes, pumping against line pressures averaging 700 pounds per square inch, a most severe twenty-four-hour service, 365 days a year.

The simplicity, reliability and flexibility of Diesel engine drive for pumping units is now established.

In the field of steam driven pumping units it has been found that approximately 600 water horsepower represents the maximum water works requirements in horizontal flywheel pumping machinery. This is equivalent to a pump capacity of approximately 15 million U. S. gallons of water in twenty-four hours pumped against a total water pressure of 100 pounds per square inch, with proportionately larger capacities, if pumped against lower water pressures.

In the vertical triple expansion flywheel type of steam driven pumping machinery, the maximum power output in useful work for which standard patterns are available, is approximately 2000 water horsepower, equivalent to an approximate unit capacity of 50 million U. S. gallons of water per twenty-four hours pumped against a total water pressure of 100 pounds per square inch.

The present standard sizes of Diesel engines as built by the Worthington Company, start at 30 H.P. single cylinder units, and are at present contemplated to extend up to 9000 H.P. 6 cylinder units.

[1] Presented before the Buffalo Convention, June 8, 1926.

[2] Worthington Pump and Machinery Corporation, New York, N. Y.

From this it may be seen that the commercial unit sizes of Diesel engines exceed by a large margin the maximum unit power available in the reciprocating steam driven pumping engine field.

In steam driven pumping machinery the steam economy for given steam conditions increases considerably with the size of the unit, while Diesel engine driven pumping units in the small sizes are within approximately 10 per cent of the economy of the largest units. This feature is of great importance.

The fuel consumption of the entire line of Diesel engines as manufactured by Worthington, from 30 H.P. up, is less than 0.5 pound of oil per brake H.P. hour, containing 18,500 B.T.U.'s per pound. On the basis of 0.5 pound per hour fuel consumption or 9250 B.T.U. per brake horsepower hour, a "duty" is developed in the oil engine prime mover equivalent to approximately 215 million foot pounds of work per million B.T.U.'s.

If this prime mover drives a centrifugal pump through speed increasing gears, with the pump and gears giving a combined efficiency of 80 per cent, the resulting overall duty is approximately 172 million foot pounds of work per million B.T.U.'s. consumed.

If the same prime mover is direct-connected to a reciprocating power pump having 88 per cent efficiency, an overall duty of approximately 190 million foot pounds of work per million B.T.U.'s is obtained.

B.T.U. duties of 172 and 190 million foot pounds developed by the small size Diesel engine driven pumps referred to above, are in the range of the maximum economies of the largest vertical triple expansion reciprocating steam pumping engines, using the highest suitable steam pressures and superheat. A B.T.U. duty of 190 million foot pounds corresponds to a duty of approximately 220 to 225 million foot pounds per 1000 pounds of steam.

For use in water works practice, the Diesel engine is suitable for

Direct connection to reciprocating power pumps.
Direct connection to screw pumps for low heads.
Direct connection to electric generators for use in driving motor driven pumps.
Direct connection to a combination of electric generator and geared reciprocating power pump.
For connection through speed increasing gears to centrifugal pumps for the customary pressures for water supply.
For driving pumps through belt or chain drive.

A typical instance of a combination of direct connected Diesel

engine, generator and geared reciprocating power pump for municipal water works service is the pumping equipment for which bids were opened at Sioux Falls, S. D., on May 25, 1926. One of the units offered at this letting had a guaranteed fuel consumption corresponding to 227 million foot pounds of useful work per million B.T.U.'s.

The Sioux Falls specifications as prepared by Maury & Gordon of Chicago, Consulting Engineers for the City, include a 400 brake H.P. vertical oil engine, a 270 K.W. generator mounted on the oil engine shaft, a belt driven exciter and a 3200 U. S. gallon per minute horizontal reciprocating power pump driven by means of a gear and pinion through a clutch from an extension of the oil engine shaft.

When this unit pumps water at the rate of 3200 U. S. gallons per minute against a total head of 190 feet, the electric generator is also required to deliver 160 K.W. at the same time.

On the basis of a combined approximate total of 370 useful horsepower in water pumped and electric energy developed by the Sioux Falls unit under the above conditions of service, the prices of the several bidders for the complete unit delivered and erected on foundations built by the purchaser, ranged from approximately $116 to $130 per useful delivery horsepower.

The present purchase of this type of pumping equipment by the City of Sioux Falls is largely due to the performance of two Busch oil engine driven power pumps installed in the same water works in 1916. Based on fuel oil at 5 cents per gallon, these units give a fuel and lubricant cost of 0.433 cents per 1000 gallons pumped against 72 pounds water pressure.

Another recent instance of one oil engine driven municipal pumping unit resulting in the sale of a second unit of the same type, due to the economy, flexibility and long life expectancy of the first 3 to 3½ million gallon unit was installed in LaPorte, Ind. in 1923. During the year of 1924 this unit pumped an average of 2,050,000 gallons per day of approximately fourteen hours, against approximately 121 feet head, at a combined cost for fuel (at 7 cents per gallon) and lubricants, of 0.456 cents per 1000 gallons pumped. The second unit installed at LaPorte in 1925 consisted of a Worthington 150 H.P., two cycle, solid injection Diesel oil engine driving a Worthington 8-inch two-stage centrifugal pump through a speed increasing gear.

On the basis of a capacity of 3 million U. S. gallons of water per twenty-four hours against a total head of 200 feet equivalent to approximately 105 useful horsepower, the price for the 1925 LaPorte

installation on a delivered and erected basis approximated $143 per useful water horsepower.

In making money comparisons of first cost of Diesel engine driven pumping equipment with steam driven pumps, particularly where a new plant is being considered, it should be borne in mind that the oil engine is complete in itself and does not require boiler house, boilers, stack, coal handling machinery and other steam auxiliaries.

A recent installation of Worthington Diesel oil engine driven power pump was at the New Britain, Conn., Water Works. This unit consists of a 150 H.P. two cylinder solid injection Blake type oil engine driving a 2000 gallon per minute power pump against a total head of 250 feet. This unit had a guaranteed duty of 3.44 million foot pounds of work per pound of fuel and on the acceptance test exceeded the guaranteed performance by nearly 3 per cent.

An installation made in 1922 at Corsicana, Texas, consisted of two units of 120 H.P. Diesel oil engines driving 6-inch centrifugal pumps through speed increasing gears. The capacity of each of these two pumping units is 1050 gallons per minute against a total head of 250 feet.

Five units, each consisting of a 600 H.P. horizontal 3 cylinder oil engine driving a forged fluid end oil line pump, are installed in one of the pumping stations of the Prairie Pipe Line Company near Buckner, Mo., pumping against approximately 700 pounds line pressure. Ten 3 cylinder vertical oil engines driving oil line pumps are in operation at different stations of the Petroleum Securities Corporation in California.

A very practical arrangement for use with motor driven units is illustrated by an installation of a 600 H.P. vertical Diesel engine direct connected to a generator and on air compressor in the pumping station at Cleburne, Texas. The electrical energy from the generator is used for municipal purposes, as well as for motor driven pumps. The air compressor supplies air for an air lift.

A Diesel engine driven pumping unit purchase of major importance was made by the Fourth Jefferson Drainage District of New Orleans, La., in 1925.

This equipment includes eight 330 H.P., 215 R.P.M., vertical 3 cylinder 17 by 25 oil engines arranged for direct connection without gears to eight 80-inch single suction screw pumps. Two of these units are installed in each of four pumping stations located on the shore of Lake Pontchartrain near New Orleans. These pumps are designed to operate between heads of 4 to 14 feet and are capable of

delivering 50,000 gallons per minute each against 14 feet head, which is at the rate of 72 million U. S. gallons of water in 24 hours each. When operating against 7 feet head, the capacity of each unit is specified to be at the rate of 102,500 gallons per minute which is equivalent to approximately 148 million U. S. gallons of water in twenty-four hours for each unit.

A duplicate installation to one of the eight oil engine driven drainage pumps referred to above is the unit erected for the Farmers Land and Canal Co., near Lake Charles, La.

If a total water pressure of 100 pounds per square inch is assumed, the smallest Worthington unit having a single 30 H.P. cylinder direct connected to a gear driven power pump, will have a capacity of 350 gallons per minute or approximately 500,000 gallons in twenty-four hours.

The same size Diesel engine driving a centrifugal pump against a total water pressure of 100 pounds per square inch would have a capacity of approximately 360,000 U.S. gallons per twenty-four hours. This capacity takes into account the gear efficiency and lower mechanical efficiency of the small size centrifugal pump as compared with the reciprocating power pump.

A 600 brake horsepower vertical oil engine unit driving a reciprocating power pump against 100 pounds total water pressure will have a capacity of approximately 12 million U. S. gallons in twenty-four hours. The same size oil engine unit driving a centrifugal pump through speed increasing gears against a total water pressure of 100 pounds per square inch will have a capacity of approximately $10\frac{1}{2}$ million gallons in twenty-four hours.

For pumping units requiring Diesel engines in excess of 600 brake horsepower, we have developed an air injection two cycle double acting vertical Diesel engine. Two of these units, each of 2900 brake horsepower at 95 revolutions per minute, built for the U. S. Shipping Board, have successfully passed the Government shop tests.

This same 4-cylinder Diesel engine, when operated at 125 R.P.M. for stationary service, would develop 3800 brake horsepower. The 6-cylinder type when operating at 125 R.P.M. would develop 5700 brake horsepower.

There is a general interest and considerable activity in the Diesel engine driven pumping unit field at present. The number of installations made by the different manufacturers is already so wide spread that this type of equipment is certain to have a constantly increasing field of usefulness in water works installations.

SEAMLESS COPPER TUBING FOR WATER SERVICE PIPES

By L. T. Reinicker[1]

As the use of seamless copper tubing for water service pipes is now generally recognized as being not only practical, but also the nearest approach to the perfect water service pipe, some of the studies made and experienced with the use of this tubing by engineers of the Bureau of Water Supply, City of Baltimore, Maryland, may be of interest.

In 1920, in an effort to solve the most vexatious problem confronting water works operators throughout the country, tests were conducted by engineers of the Bureau of Water Supply with various new materials and the adaptations of old materials used in the manufacture of pipes for the smaller water service connections.

Practically all the then known pipes for service were considered in our studies, but no definite results were obtained until experiments were made with a seamless copper tubing.

Our attention was first attracted to the use of copper tubing by a paper written by a German engineer about six years ago on the advisability of using such materials for service pipes. The name of this engineer has been forgotten. In fact, we do not even have a record of where his paper was published, although to us his thoughts have been almost invaluable.

At about this same time in the demolition of part of one of our pumping stations a piece of copper spouting, which had been underground and was about forty-five years old was discovered and found to be in practically perfect condition. From an examination made by the Director of the Bureau of Standards, Baltimore, it was believed there were great possibilities in the use of such material for water service pipes.

Shortly after this the Mueller Company, mainly, I believe, through our investigations, started the manufacture of a seamless copper tubing for water service pipes. Some of this pipe was immediately purchased and 25 services were installed. In addition various tests were made on this copper tubing as enumerated below.

[1] State Manager, North American Water Works Corporation, Lexington, Ky.

Our chief chemist after tests found no evidence of soluble copper after water had been standing in the pipe for some time.

For testing purposes 3 services were allowed to freeze solid from the connection in the main to the stop at the curb. The services were then thawed, requiring about 5 minutes, and the pipe was inspected. The tubing did not burst, as is the usual case when galvanized wrought iron pipe is frozen, and there was no evidence of a leak, crack or damage of any kind.

We found, also, that, while the copper tubing did not prevent electrolytic actions, it delayed the final result of electrolysis, in that this action was spread over a greater part of the pipe and was not concentrated in one particular spot as it is in the wrought iron pipe.

After finding, also, the ease with which the pipe could be installed by the average foreman and crew; the speed with which it could, also, be installed; that about one-fifth the time was required to install as for a wrought iron service; the smaller trench required; the saving in time and labor, which, although the cost of the pipe was more than of wrought iron pipe, balanced the total cost to about equal with the wrought iron service; and the possibilities of longer life; we decided to standardize on the seamless copper tubing for all $\frac{3}{4}$- and 1-inch water service installations.

While we had no actual facts to prove a longer life for copper tubing, the past history of the longevity of copper under various conditions tended to substantiate our hypothesis that its life under normal conditions would almost be indefinite.

Specifications, modeled to a great extent after government specifications for copper tubing, were then prepared specifying the cold drawn tubes. Some of the first copper tubing installed was the soft annealed, with which considerable trouble was experienced. Special care had to be exercised in the handling of this pipe particularly in storing and transportation in trucks. The pipe bent so easily that an overhand from a truck, ordinary storing or handling would cause it to sag. Furthermore, when it was actually desired to bend the tubing it became distorted and unsymmetrical, thus destroying the true cross section of the pipe.

All of the above, of course, tended to dissuade us from the use of the soft annealed tubing and the cold drawn was therefore specified. These specifications are appended.

Although the hazard in driving service pipes in cities, where a multiplicity of sub-surface structures are always present, tends to

prevent this practice to a great extent, we also had some experience in driving. Particularly in some of the outlying sections of the city on side streets we have successfully driven copper tubing by jetting. A hose is connected to one end of the pipe and water turned on. By continually jabbing the pipe forward the water does the cutting, washing the dirt out at the end of the pipe.

We have had success, also, in first driving a piece of wrought iron or steel pipe, withdrawing it and then inserting the copper tubing in the hole remaining. Of the two methods we recommend jetting as being the most economical and satisfactory.

SPECIFICATIONS

16. Manufacture. The pipe furnished under this contract shall be seamless copper pipe, cold drawn to size, suitable for use as house water service pipes.

17. Measurement. The measurements of the pipe shall be as follows:

Nominal size	$\frac{3}{4}$ inch	1 inch
Inside diameter	$\frac{3}{4}$ inch	1 inch
Outside diameter	$\frac{7}{8}$ inch	$1\frac{1}{8}$ inch
Wall thickness B.W.G.	no. 16	no. 16

Furnish in the following lengths:

Lengths	*Quantity* $\frac{3}{4}$ inch	*Quantity* 1 inch
14 feet 0 inch	——	——
16 feet 0 inch	——	——
18 feet 0 inch	——	——
20 feet 0 inch	——	——

18. Chemical composition. The copper pipe shall be made from deoxidized copper and shall have a purity of at least 99.88 per cent, as determined by electrolytic assay, silver being counted as copper. Samples for chemical analysis shall consist of drillings taken from test specimens of the pipe.

19. Standard weights and allowable variations. One cubic inch of the material is assumed to weigh 0.323 pound and the weight of any pipe shall not vary more than 5 per cent from the theoretical weight. The thickness at any point shall not be less than that specified by more than 5 per cent.

20. Workmanship. The pipe shall be round and of uniform thickness throughout. They shall be free from cracks, seams, slivers, scale and other surface defects.

21. Preparation for shipment. Pipe may be shipped in bundles weighing not more than 150 pounds each. They shall be securely tied in several places so they may be handled without danger of becoming untied.

22. Bidder to submit samples. The bidder shall submit a sample 36 inches long of each size of the copper pipe that he proposes to furnish under this contract. These samples shall be delivered to the Bureau of Water Supply, Room 205, City Hall, Baltimore, Maryland, on or before the date of opening

bids, and no bid will be considered unless such samples have been submitted.

23. Test specimens. Tension test specimens shall consist of a full section of unannealed pipe. The ends shall be plugged with metal plugs, which shall not extend within the gage marks.

Bend test specimens shall consist of a strip not over $1\frac{1}{2}$ inches in width, cut longitudinally from the pipe.

24. Tensile tests. The test specimens shall develop a minimum tensile strength of 40,000 pounds per square inch with a minimum elongation of 10 per cent in 4 inches.

25. Bend tests. The bend test specimens, shall withstand being bent flat on itself through 180 degrees while cold without cracking on the outside of the bent portion. Full sections of the pipe shall withstand being bent cold through 180 degrees without cracking on the outside of the bent portion, around a pin, the diameter of which is $1\frac{1}{2}$ times the inside diameter of the pipe. This test shall be in addition to the test hereinbefore specified.

26. Flange tests. A full section of pipe not more than 4 inches in length shall have a flange turned over at right angles to the body of the pipe without showing cracks or flaws. The width of this flange, as measured from the outside of the pipe, shall be $\frac{1}{4}$ of the inside diameter of the pipe. In making these tests, the flaring tool and die block described and shown in the A. S. T. M. Standard Specifications for Copper Pipe, Serial Designation, B42-24, shall be used.

27. Hydrostatic tests. Each pipe shall withstand, without showing weakness or defects, an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 6000 pounds per square inch determined by the formula for thin hollow cylinders under tension: $P - \frac{2ts}{D}$, in which P equals the pressure in pounds per square inch, t equals the thickness of wall in inches, D equals the outside diameter of the pipe in inches, and S equals the allowable unit stress of the material, 6000 pounds per square inch. This equals approximately a pressure of 900 pounds per square inch for the $\frac{3}{4}$-inch pipe and 700 pounds for the 1-inch pipe.

28. Shop tests. Each pipe shall be subjected to the above mentioned hydrostatic pressure test at the place of manufacture. The other tests shall be conducted on samples selected at random, one sample being taken from and representing each 5000 feet or less or pipe applying on this order.

29. Tests by the Bureau of Water Supply. After delivery of the copper pipe test pieces shall be cut from the finished pipe as delivered and they will be subjected to the above mentioned tests at the Bureau of Standards, Baltimore, Maryland.

30. Proportion of shipment tested. At least one sample shall be taken from and shall represent each 5000 feet or less of the pipe delivered. This sample shall be cut from the end of a pipe selected at random from the particular lot in which it is delivered. However, should this sample fail under test, two additional samples shall be cut from the same lot of pipe and these will be tested. In case both of these additional samples do not pass the above specified tests, the pipe in the lot delivered and represented by them will be rejected.

31. Causes for rejection. Should the results of these tests be below the requirements of these specifications, all copper pipe made from the same material as the test pieces shall be rejected, and the delivery of the pipe returned to the contractor at his own expense. In such event, the City may purchase in the open market, such quantity of pipe required to supply the deficiency by such failure; or the City may annul the contract by giving notice in writing to that effect to the Contractor; and in that case, the City may, in its discretion, purchase in the open market or by contract upon competitive proposals, all such pipe as may be required to complete the contract.

32. Claims for rehearing. Samples of rejected copper pipe will be held at the Bureau of Standards for two weeks from the date of test report.

Accordingly, in case of dissatisfaction with the results of the tests, the contractor must make claim for rehearing, should he desire to do so, within that time. Failure to raise the question within two weeks will be construed as evidence of satisfaction with the tests. The samples will then be scrapped and no further claims for a rehearing will be considered.

33. Contractor liable for damages sustained. In case the City shall purchase copper pipe in the open market, or by contract as above specified, the contractor shall remain liable for all damages sustained by the city on account of his failure to fulfill the contract, including the difference, if any, between the cost of furnishing and delivering said pipe and the price at which said contractor agreed to furnish it, and any action taken in pursuance of the above provision of the contract shall not affect or impair any right or claim of the city for damages for breach of any of the covenants of the contract by the Contractor.

METER REPAIRING[1]

By Thos. C. Lynch[2]

In Rochester we have 17 different makes of meter in service, ranging in numbers of each make in use, from twenty-five to thousands. For 15 of the 17 makes we carry repair parts in stock. The manufacture of the other 2 makes has been discontinued. Some of these meters have been in service for more than 30 years, being removed for repair when out of order, or being removed for test when they have not been removed for any other cause after a number of years. Each meter as it is brought into the shop for any reason, except in cases where it has been in the shop for repair during the preceding year, is taken apart, cleaned, and each of the component parts is examined as to its condition. If any part is worn enough to require attention, it is refitted if that is possible, if not a new part is substituted.

The percentage of accuracy which we require in new meters just received from the factories is from 98 to 102. This percentage is adhered to closely in our tests of repaired meters.

Meters that have been in constant service for a period of years without ever having been removed for any cause, are brought in a few at a time, and are tested as to accuracy. A record is kept of this test, but even if it shows a degree of accuracy within our requirement the meter is taken apart, examined, and treated in the same manner as though it had stopped registering, to make sure that some of its working parts are not on the point of giving way. After the meter has been given this attention, and has been reassembled, it is tested again. Both of the tests are entered on our records as test before repair and test after repair. The meter is reset on the service from which it was removed if its size was $\frac{5}{8}$, $\frac{3}{4}$ or 1 inch.

On any size of meter above 1 inch it is our practice to keep a meter of each size in the shop which has been repaired and tested. When we have occasion to remove a meter of any size above 1 inch we take

[1] Presented before the New York Section meeting, October 28, 1927.

[2] Foreman of Meter Repair Shop, Water Works, Rochester, N.Y.

the meter of the required size which we have in stock, and set it in place of the meter which is to be removed. The removed meter is brought to the shop, is repaired and tested, and is held to be used as occasion requires.

The plan of taking large sizes of meters apart on the premises on which they are set, and installing new parts or entire new interiors, has never been favored here. It is done only when a meter has been so surrounded by other piping, partitions, etc., as to make it difficult to remove. While repairing a meter on the premises puts it in working order again, and its registration after being so repaired may show the usual average consumption, our practice requires that when one of our meters of any size needs repairs we shall have on our records the exact degree of accuracy to which it registers. This of course makes it necessary to bring our meters to the shop unless we were to make use of portable testers, which we do not favor in comparison with our shop equipment.

Our cost of maintenance per meter in 1926, with approximately 58,000 meters in service, was 50 cents. I have seen figures given in yearly reports in other cities, in which the cost of maintenance per meter was lower than ours. A few years ago I saw figures given in one very large city having double the number of meters in service as compared to ours, which gave the maintenance cost per meter as 12 cents. As this was the record low figure I had seen, I requested our superintendent to write to the men in charge of meter affairs in that city for more detailed information as to how they repaired meters. He did so, and the reply stated that the majority of the meters referred to in the report, had been removed for test only and that if, when tested, a meter was as good as 10 per cent nothing more was done to it except to reset it. The answer did not state whether they ran fast or slow, but simply that 10 per cent was good enough. This answer seemed to explain most of the difference between 12 and 50 cents maintenance cost.

In cities doing their own repairing, having a large variety of makes of meters in use, carrying repair parts for each make of meter, and requiring a close degree of accuracy in a repaired meter, the cost of maintenance per meter is higher. But the amount of revenue received by the city from metered accounts must also be higher. While in cities doing their own repairing, but having a limited number of makes of meters in service, carrying a smaller stock of repair parts,

and allowing a greater degree of latitude in the degree of accuracy required in a repaired meter, the reverse must be true.

It follows that, if a very liberal allowance of accuracy is in force, say from 5 to 10 per cent for repaired meters, much saving in time, labor, and in the use of meter parts is effected, and a lower cost of maintenance is bound to result. It also follows, however, that the degree of accuracy in such a meter is much less than in the case of the repaired meter in the Department requiring the 2 per cent degree of accuracy, and which brings each meter to the shop and makes a thorough inspection of its interior when for any reason it requires attention.

We remove between 4,000 and 5,000 meters per year for various reasons, such as not registering, damaged by freezing, damaged by hot water, property vacant, test, leaking etc. There are very few removed which are not put through the regular routine of taking apart, cleaning, and examinination of all parts. The reason for excepting those which are not taken apart, is that they have had that treatment within the preceding year. We render bills to the property owners for the labor and material cost of repairing meters which have been damaged by freezing, by hot water, or for damage caused to the meter by carelessness of the owner or tenant of the property which the damage meter covers. Repairs to meters for other causes are not charged for.

THE GRAPHIC WATER LEVEL RECORDER[1]

By C. C. Covert[2]

Finding a simple but effective way of measuring the flow of water to and from water treatment plants is one of the problems confronting the designing engineer. While there are several types of flow meters on the market, the cost of their installation often is prohibitive. Consequently we find many plants struggling along without proper records.

If the plant is so designed that the discharge into and out of the filters can be made to pass over a weir, it is quite a simple matter to provide a record sheet for the water level recorder which will give the m.g.d. flow as well as the elevation of water surface in the pool.

The question of proper installation is important, but if given timely consideration one may bring all of the gages to a central point for housing and so arrange them that their care in operation is as simple as that of any other type of instrument. The cost of installation, including the instruments, might be considerably less than many types of flow meters.

The water works system at East Orange, New Jersey, has a practical use of the water level recorder along these lines. The gage operates a float in a stand-pipe and shows the m.g.d. passing over the weir. The record also tells the story of the pump. In case of a shut down the water drops very rapidly to the low point in the crest and also soon comes back to the original level when the pump again becomes active. Thus the superintendent not only has a record of the flow, but he also has a measure of the time the pump was down. I might refer to other cases, but this offers a suggestion and, after all, each problem is governed by local conditions. The outstanding fact is, however, that the ordinary water level recorder can be made to tell this operating story if properly installed.

One other problem of growing importance in providing an adequate water supply is that of storing the flood waters for use dur-

[1] Presented before the Chicago Convention, June 10, 1927.

[2] With W. and L. E. Gurley, Troy, N.Y.

ing the low water season. The storage reservoir needs the water level recorder to tell the story of change in water surface elevation. I am admitting that it is not absolutely necessary to provide this equipment, but the cost is so small when its installation is provided for in the original plans and the data may be of such great value in the after consideration or studies of the water surface in the reservoir that to omit it really seems an economic waste.

All of this increased demand for water throws a larger load upon the original source of supply and it is opportune to say something about this keeping of original records which I fear is too often neglected.

Stream-flow records are the outstanding data which, if properly assembled, will go a long way towards making the storage reservoir and the filter plant just what they should be for each job. This work is no longer new or of uncertain caliber for through the medium of the Water Resources Branch of the United States Geological Survey, we have come to know that it is possible to obtain records of the run-off of practically any drainage basin.

The engineers of this Bureau through a long period of years, in which they have carried the work of gaging streams to nearly all parts of the United States, have demonstrated that:

(a) A continuous record of the discharge can be obtained.
(b) All regulated streams and most streams of small drainage areas need recording gages.
(c) With recording gages installed and operated under proper supervision, the records of daily as well as monthly and yearly flow will have a degree of accuracy well within the limits of practical use.
(d) The value of stream flow records is measured largely by their duration.
(e) The minimum record period should be not less than five years.

With this present-day knowledge of the work of gaging streams and compiling the records of run-off and with the demonstrated value of these data in the design and operation of a water works system, we are able to produce records which will tell the story about the present source of supply and will point out the best source for additional supply when needed. This is one of the big jobs of the present day waterworks official. The day is not far distant when such duties will be compulsory by law, for knowing the limits of production of

the active drainage area or the immediate source of a new supply is just as much a part of their official duty as collecting the water rents when due or repairing a broken main.

While there is a growing tendency to keep better records, a survey of the water works systems of the United States would no doubt reveal the fact that there were a large number of water companies who were keeping no records to show possible sources for additional supply and far too many that could not give dependable records as to the limits of the present source of supply.

COÖPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY

From the standpoint of efficiency, it would be well for all public service corporations, municipalities and others interested in any problems which involve the use of water, to seek coöperation with the engineers of the Survey, to the end that all such data may be collected for publication in the official reports or water supply papers issued by the Federal government. This coöperation I am firmly convinced cannot be urged too strongly, since it insures the services of an experienced engineer in locating the station and designing and placing the equipment. This feature is essential to good records, for without a proper location and proper field equipment at the station, complications are certain to arise which will have a tendency to discredit all, or at least a part, of the records obtained.

LOCATION OF GAGING STATION

A thorough reconnoissance is necessary in connection with the establishment of any gaging station. The engineer should be certain that he has selected the best site available. With modern equipment, one is no longer confined to the vicinity of some farm house or highway bridge. The recording gage and the cable way have practically eliminated these conditions as controlling features, and today we can select the location which will produce the best results.

The engineer who realizes the importance of a permanent control, well defined channel conditions, suitable place for metering and for the location of the gage, and who gives all of these features mature consideration, will be able to reduce his operating costs and turn out final results—discharge in cubic feet per second—in a much more complete form.

The proper location of the gage with reference to the control is also

of importance. Any interference here has much the same effect as shifting control.

The gage should not be placed so close to the confluence of a tributary stream that the readings will be affected by back water at certain stages, or on the up stream side of a bridge where log or ice jams may cause back water conditions.

TYPE OF GAGE

The type of gage is important. Some streams will be well taken care of by the ordinary staff or chain gage, while others will require

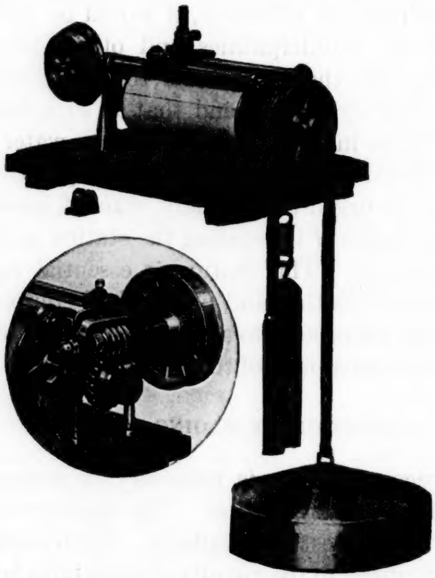


Fig. 1. Graphic Recorder. Insert Shows Gear Attachment

recording gages. When one has decided to use a water level recorder, then to choose the proper type and to plan for its suitable housing is the next step of importance. Right here let me say that the shelter and the well should be more than toy structures. There is no question as to the value of having a building large enough to permit a man to enter, close the door, and work fully protected from the weather. Proper ventilation of both the well and shelter is another feature which should be given careful consideration. The well should be at least 3, or better 4, feet square. In the northern coun-

tries it should be located well back in the bank where sufficient earth protection will assist in keeping ice from forming. If of timber, the structure should be of double plank separated by a layer of heavy tar paper. The shelter should be of the same dimensions, in cross-section, as the well. It should be built up of $\frac{7}{8}$ inch ship-lap covered with either tar paper or heavy building paper and then shingled. At least one window should be provided with a heavy board blind as a means of protection. Stock doors may be used, but these should fit tightly and in the winter provision should be made to close this door so that the storms and winds cannot enter.

The intake pipe to the well is another important consideration. Four-inch cast iron pipe or iron soil pipe is suitable for this use. The outer or river end should be anchored with a concrete pier. This end should also be covered with a screen to prevent as far as possible any foreign matter entering the pipe. Each recording gaging station should be equipped with both an inside and outside gage, for the purpose of more economically and accurately checking the operation of the intake pipe. These gages should be referred by means of an engineer's level to some permanent bench mark.

MAKING THE DISCHARGE MEASUREMENT

After the gage has been installed and is in operation, the next step of importance is the development of the rating curve. The Price current meter as manufactured today meets in a very satisfactory manner most of the problems connected with the regular stream gaging work. When used under favorable conditions, and this the engineer must be on the watch for when choosing the site for the gage, there is no question but that the accuracy of the Price meter is all that could be desired. Engineers from the water resources branch of the United States Geological Survey working in coöperation with the Gurley factory simplified the construction of the Price meter so that contacts for indicating each revolution and each fifth revolution of the bucket wheel are contained in one contact chamber or commutator box. Two binding posts on the outside of the contact chamber make it easy to change from single to penta indicating or vice versa.

There is also a new type of binding post, whereby the strain is carried by metal rather than the fiber bushing. The ends of the screw are upset so that the nuts will not become lost.

Frequently in the location of a gaging station, highway bridges or other structures suitable for use in making the discharge measurement will be found available. It often happens, however, that to secure the best location possible it is necessary to build some structure from which the measurements may be made. Standard equipment for this feature is a cable stretched across the river from which a car can be slung for the use of the engineer. Riding back and forth across the stream in this equipment, he is in a position to take observations of the velocity at any desired point. After each discharge measurement, the meter should be thoroughly cleaned and oiled.

For small streams and for low water conditions in the larger streams, it is often possible to make discharge measurements by wading. Measurements are made covering a range from low water to high water. The results of these measurements are then plotted on regular cross-section paper with the gage heights and discharge in cubic feet per second as coördinates, and through these points a smooth curve is plotted. From this curve one can compute the discharge rating table, which when properly constructed, makes the problem of tabulating the daily discharge or, in some cases where the water stage register is used, the hourly discharge, comparatively simple.

After the daily discharges have been taken out for the period of the record—usually these are worked up each year,—at least a tabulation is made which shows these results in monthly form, giving not only the daily discharge in cubic feet per second for each day, but the monthly mean in cubic feet per second, etc. When published in the Water Supply Papers of the United States Geological Survey, these data become available to engineers throughout the country.

MEASURING SMALL STREAMS

In the first place, these streams are flashy, responding quickly to heavy showers and during a long drought there is apt to be a large diurnal fluctuation due to daytime and night temperature. The problem of obtaining the records of discharge during the winter months is also very difficult to handle. These streams should be equipped with weirs for control and recording gages for gage heights. It is practically impossible to measure the low flows with a meter, especially during the winter months. It has been my experience

that the most satisfactory manner in which to handle this problem is to construct a weir and use this as a control, rating the weir in the same manner as you would rate a regular current meter station. The notch in the weir should be about large enough to carry the winter flow at a depth of 5 or 6 inches. The observer can then very easily keep the ice broken back for 6 or 8 feet from the weir and the records will be as accurate as in open water conditions.

OBSERVATIONS ON PURIFICATION PLANT REPORTS

By James W. Armstrong[1]

The matter of securing more uniform purification plant reports has lately been the subject of some comment among a number of men responsible for plant operation. The present discussion is submitted with the thought that it might stimulate further discussion of the subject which would hasten the day of more uniform reports.

If a purification plant operator had only himself to consider, the form in which he keeps his records would make little difference, but when his reports are made public, the form in which they are kept becomes a matter of considerable importance. The making of a carefully detailed uniform monthly report, arranged so as to be easily interpreted, has a two fold value. It affords the operator reliable data for checking his plant performance against his own past records and of comparing his plant with others.

Reports should be made in sufficient detail and recorded in such a way as to permit each step in the sequence of plant operation to be easily compared with other steps in the purification process and to be studied independently. If each kind of a record is kept on a separate sheet, as is done in some plants, it makes it very easy to study the particular phase of plant operation recorded, but difficult to compare the different steps in the plant performance, or to get a clear idea of what the plant is doing as a whole.

Some time ago, an effort was made to compare the performance of Montebello Filters with a number of other plants. An exchange list of monthly reports was established for the purpose. As time went on, it became evident that some of the reports were very helpful and that others were of little or no value as a means of comparison.

The reports made in terms of general monthly averages were of no assistance in checking plant operation, whereas those reports recording each separate operation each day, enabled us to make very exact comparisons, and to plot curves, showing daily and seasonal

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variations, or any unusual occurrence that might not be apparent from the inspection of a large mass of figures.

The form of monthly report now in use at Montebello has been gradually evolved, slight changes being made from year to year as experience seemed to warrant. They are all made 11 inches wide, and of any desired length. They can then be folded to fit any standard $8\frac{1}{2}$ by 11 inches binder and can be kept in a desk drawer, or on a book shelf. The blank form was originally made on tracing

Day	Million Gallons Treated	Filters						Temp. Fahr.		Chemicals						
										Alum		Lime			Chlorine	
		Units Washed	No. Out of Service	Aver. Time of Wash	Aver. Time of Service	Million Gal. Wash Water	Percent Wash Water	Air	Water	Pounds	Grains per Gallon	Pounds	Grains per Gallon	Percent Strength	Pounds	Parts per Million
				Min.	Hrs.											
1																
2																
3																
29																
30																
31																
Total																
Aver.																
Median																
Max.																
Min.																

Fig. 1

cloth, and in order to save the trouble of printing the headings each month, was reproduced on tracing cloth at a reasonable cost. After the reports are filled in, about fifteen blue prints are made and mailed out each month.

The value of such report forms lies in the fact that the essential data for each day's operation occupies but a single line, making it easy to study the entire plant performance and to catch any unusual condition that may arise. The vertical columns each contain a monthly record for the subject indicated by the heading.

Figure 1 shows a portion of the monthly report relating to the physical and chemical properties of the water; figure 2 shows the

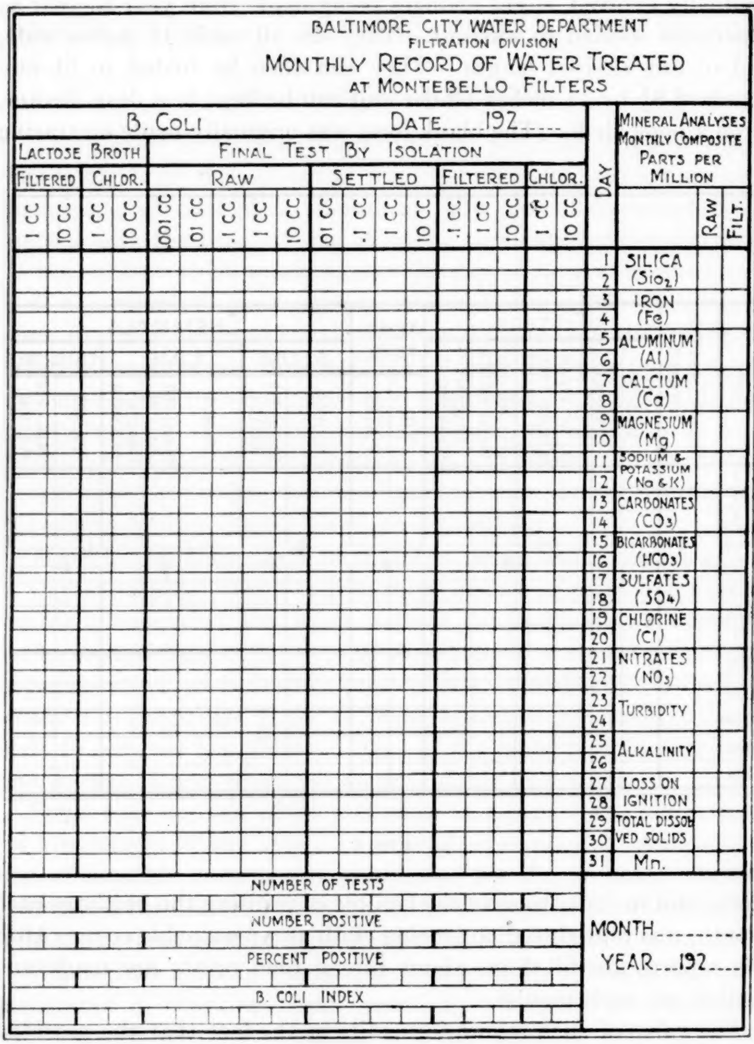

FIG. 2

bacterial results, and figure 3 shows all the headings of the report blank, which in reality extend in a single line across a sheet about 37 inches long.

In the earlier years of plant operation, it was our custom to make the annual reports in the form recommended by the New England Water Works Association. During the last few years, however, the annual report has been made to coincide in form with the monthly report, the monthly averages only being recorded. As the monthly

Day	Million Gallons Treated	Filters						Temperature Fahr.		Chemicals							
										Alum		Lime			Chlorine		
		Units washed	No. out of service	Aver. time of wash	Aver. time of service	Million gal. wash water	Percent wash water	Air	Water	Pounds	Grains per gallon	Pounds	Grains per gallon	Percent strength	Pounds	Parts per million	P.P.M. residual
				Min.	Hrs.												

Suspended Matter							Color		Hardness							pH			CO_2		Iron			
Turbidity				Percent Removal					Available Alkalinity			Non Carbonate		Soap										
										Filtered														
Raw	Basin 1	Basin 2	Filtered	Basin 1	Basin 2	Total	Raw	Filtered	Raw	Total	Mono Carb.	Raw	Filtered	Raw	Filtered	Raw	Mixing Basin	Filtered	Raw	Filtered	Raw	Basin 1	Basin 2	Filtered

Dissolved Oxygen % Sat.		Oxygen Consumed		Micro Organisms Raw Water		Bacteria per CC							
						20° C. on Agar				37°C. on Agar			
Raw	Filtered	Raw	Filtered	Number per cc	Volumes per cc	Raw	Settled	Filtered	Chlorinated	Raw	Settled	Filtered	Chlorinated

Percent Removal					B. Coli													
Bacteria 37°					Presumptive Test in Lactose Broth													
			Total		Raw					Settled				Filtered			Chlor.	
Settled	Filtered	Chlorinated	Filt.	Chlor.	.001 cc	.01 cc	.1 cc	1 cc	10 cc	.01 cc	.1 cc	1 cc	10 cc	.1 cc	1 cc	10 cc	1 cc	10 cc

Date ______192____														Day	Mineral Analyses Monthly Composite Parts per Million		
Final Test by Isolation																	
Raw					Settled				Filtered			Chlor.					
.001 cc	.01 cc	.1 cc	1 cc	10 cc	.01 cc	.1 cc	1 cc	10 cc	.1 cc	1 cc	10 cc	1 cc	10 cc			Raw	Filt.

Fig. 3

report could not be reproduced photographically without making the figures too small to be read, it was divided into two parts; the physical and chemical properties of the water being reported on one sheet, and the bacterial report was made on another sheet.

The matter of recording the depth and grading of sand in the

filter beds by plotting the sievings on logarithmic paper and computing the effective size and uniformity coefficient, is to the writer

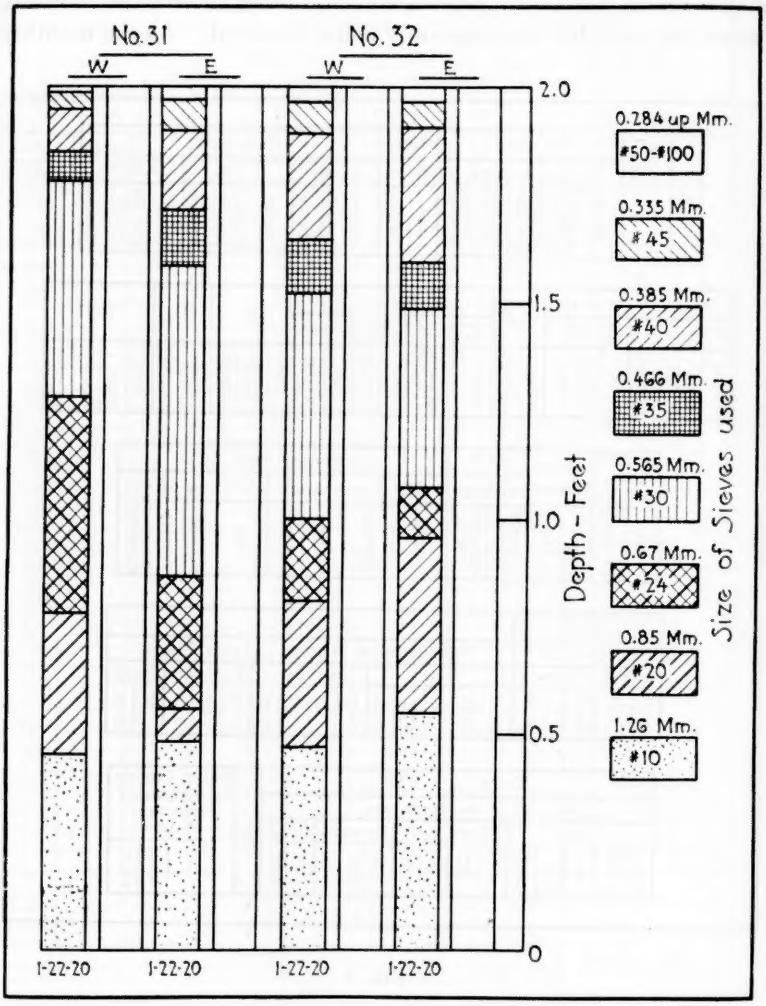

Fig. 4

very unsatisfactory. At Montebello Filters we have 32 different filter units, each one of which is divided into two parts by a center gutter. When sand was first placed in these filters it was secured

from different localities. A careful analysis was made of the sand in each filter and the results were plotted on standard logarithmic sand charts. A careful study of these charts failed to convey any real comparative picture of the sand in the different filter beds. Later it was found that the sand grains were increasing in size, due to the gradual coating of lime. Samples were again taken from each filter and a careful analysis made. This time they were plotted on a sheet very much in the same manner that test borings on soil are usually recorded. As the top of the sand layer is the most important feature in making comparisons, the tops were all considered as starting from a given line, regardless of the depth of the sand. By plotting all the filters on a single sheet, it was very easy to determine the depth of sand passing each different sieve, and in this way fairly accurate comparison could be made.

This form of plotting sand may meet with the objection that it does not consider the ordinarily accepted terms "effective size" and "uniformity coefficient." These terms were originally worked out in connection with slow sand filters where sand was taken from its natural bed and placed in the filters, remaining in practically the same condition.

For slow sand filters the terms probably cannot be improved upon, but for mechanical filters, where immediately after washing the sand becomes hydraulically graded, the term "effective size" can have no practical meaning and is liable to be very misleading. "Effective size," if the word can be used without confusion in its ordinarily accepted meaning, is the very top layer of sand, however thin it may be, as the instant floc strikes this layer, it invariably breaks. Figure 4 shows the method of plotting. The symbols might be changed to make greater contrast between the various sizes.

THE QUANTITATIVE ESTIMATION OF PLANKTON[1]

By Wilfred F. Langelier[2]

It is the object of the writer in this paper to discuss briefly the methods and apparatus available for the quantitative estimation of algae and other forms of plankton, the presence of which in water supplies may be the cause of more or less serious deterioration in the aesthetic quality of the water.

There are two essentially different methods for the estimation of plankton. The Sedgwick Rafter method (1), developed in the late eighties in this country, and the plankton net method of Hensen (2), developed at about the same time in Europe. The Sedgwick Rafter method as described in the several editions of the A. P. H. A. Standard Methods of Water Analysis is very well and favorably known in this country and need not be described in detail at this time. The method was invented and developed by pioneer sanitarians (3) and is to-day the method employed almost exclusively by the members of that profession. The net method, on the other hand, was developed by the hydro-biologist, and continues to be the method most frequently used by that group. Several modifications of the two methods have been developed and each has its supporters within each group of workers.

The writer, viewing the problem from the standpoint of the water-works man, believes that, although the Sedgwick Rafter method offers the greatest advantages as a "Standard" laboratory method to be used for the examination of a given sample of water, the net method of sampling and enumeration is to be preferred generally for the routine examination of large reservoir supplies where the object of the examinations is the study of the development cycles of the various

[1] Presented before the Water Purification Division, Chicago Convention, June 10, 1927. Prepared as a preliminary report to the Standardization Council, Committee No. 1 (Standard Methods of Water Analysis), by the Sub-Committee on Microscopical Methods.

[2] Associate Professor, Sanitary Engineering, University of California, Berkeley, Calif.

plankton, for purposes of preventive treatment or other means of controlling tastes and odors.

The Sedgwick Rafter method is generally assumed to involve errors approximately as follows (4): Funnel error 1 to 10 per cent, sand error 2 per cent, decantation error 1 to 12 per cent.

These are the apparent errors and they are entirely negligible as compared with the absolute errors of sampling and the failure to catch the smallest algae. The distribution of plankton, both vertically and horizontally, in a large body of water, is very uneven. Bottle collection of samples presupposes that in many instances certain troublesome organisms may be missed altogether. Incidentally, the pipe method of collection in preference to bottle collection is deserving of further study.

Another serious objection to the Sedgwick Rafter method has to do with the method of enumeration. A direct count of the organisms or standard cubical units is very tedious. Direct volumetric measurement of the organisms is complicated by virtue of the small catch and the relatively large volume of impurities contained. The centrifuge has been used for this purpose by Purdy (5).

The two principal objections to the Sedgwick Rafter method, namely, the sampling error and the difficulties of enumeration, are overcome to a considerable degree by the net method. In this method the sample is concentrated or filtered at its source; that is to say, a net of fine silk bolting cloth, made in the shape of a cone, is hoisted through the water, thereby straining the plankton from a column of water which, without correcting for the displacement error, is equal in volume to the product of the circle area and depth of haul. Thus a net having a circle diameter of 30 cm. hoisted from a depth of 15 meters, would filter 1.16 cubic meters or 304 gallons of water. If the filtering area of the net is assumed to be five times the circle area, and if the haul is made at the rate of 0.5 meter per second, the rate of filtering would be 6.5 cc. per square centimeter per minute (1.6 gallons per square foot per minute). Similar computations for the Sedgwick rafter method show that the rate of filtration for this method is roughly comparable. The net method, however, provides for the concentration of approximately a one thousand fold larger sample. This eliminates of course to a considerable degree the sampling error due to uneven vertical distribution of the plankton, and at the same time yields a catch, the volume of which may be readily measured. This may be accomplished by simply allowing

the concentrate to stand in a graduated tube. After measuring the volume of the catch the results may be reported in cubic centimeters per cubic meter of water, which of course is the same as parts per million by volume. This latter method of reporting (parts per million by volume) appears to the writer to have merit since it conveys to the mind more accurately perhaps than other methods, the extent of the growth.

If it is desired, an actual count of the various forms present may be made by diluting the catch to a known volume and pipetting off an aliquot portion for examination under the microscope. More often, however, all that is needed is a percentage estimate of the predominating or troublesome types and with little experience this can be quickly and readily made. The catch obtained in this manner is relatively free from silt and other foreign matters, thus making the microscopic examination easier.

In the writer's laboratory two modifications of the net method of estimating plankton are in use. The procedures differ only in the size of net employed and in the methods of handling the catch. One procedure employs a 12-inch net with a 4-inch (one-half pint) stoppered copper bucket or container attached to the bottom to receive the concentrate or catch. After hauling, the net is doused with water to wash down the organisms adhering to the silk. The contents of the bucket are transferred to a one-pint fruit jar to which has been added 5 or 10 cc. of formaldehyde. In this condition, if desired, the catch may be kept almost indefinitely. In the laboratory, the catch is further concentrated by filtration, through a Buchner funnel, using a hard-surfaced filter paper. By means of a wash bottle containing 10 per cent formaldehyde the catch is transferred from the filter paper to one or more centrifuge tubes and its volume ascertained. The result is computed in cubic centimeters of algae per cubic meter of water or parts per million by volume. A portion of the catch is then examined under the microscope and percentage estimates are made of the one or two predominating forms.

The modification of this procedure, which we have found to be well suited for routine reservoir control work and which may be safely entrusted to persons not skilled in laboratory technique (as for example reservoir caretakers), consists in using a much smaller net and a glass centrifuge tube as a receiver. Our small nets have a 4-inch ring and the receiver is a standard 50 cc. centrifuge tube with 0.5 cc. or smaller divisions. In this procedure, after making the

haul, the receiver is detached from the net and placed in a rack, and a direct reading of the volume is taken after sedimentation has taken place. If crustacea or rotifera are present, and they usually are, or if it is desired to preserve the catch, a few drops of formaldehyde are added to the tube. A record of the volume and the character of the catch is made as in the first procedure. In some instances a portion of the catch may be lighter than water, in which case the floating volume is read off and added to the settled portion. The results obtained by the net method are in such form that they may be plotted conveniently (see fig. 1).

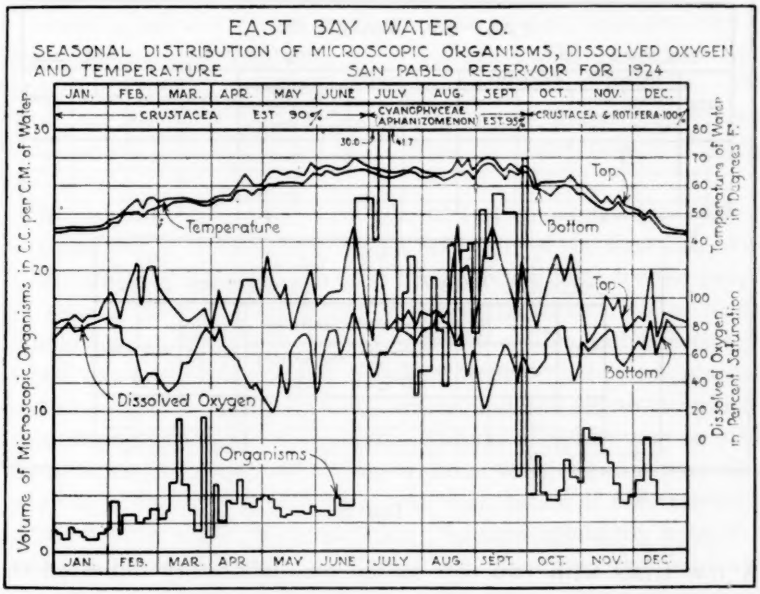

FIG. 1

Unfortunately, however, the net method is not without its limitations. There are two fundamental sources of error (1), the estimation of the volume filtered, which we may call the water deflection error, and (2) the error due to imperfect filtration, which we may call the leakage error. Both of these errors would normally give low results.

In hoisting the net through the water a part of the column of water traversed is pushed aside and accordingly a "net factor" is commonly

used in correcting for the volume of water filtered. The factor for a given net depends upon a number of variables, for example, mesh size, hoisting velocity, ratio of filtering surface to area of circle, density of algal population, etc. A net of proper dimensions of No. 20 silk bolting cloth, drawn through the water at the rate of 0.5 meter per second should have a factor of approximately 2.0. That is to say, such a net would deflect one-half of the column of water traversed. Methods of determining the net factor for a given net have been worked out by Hensen (6), Reighard (7), and Birge (8).

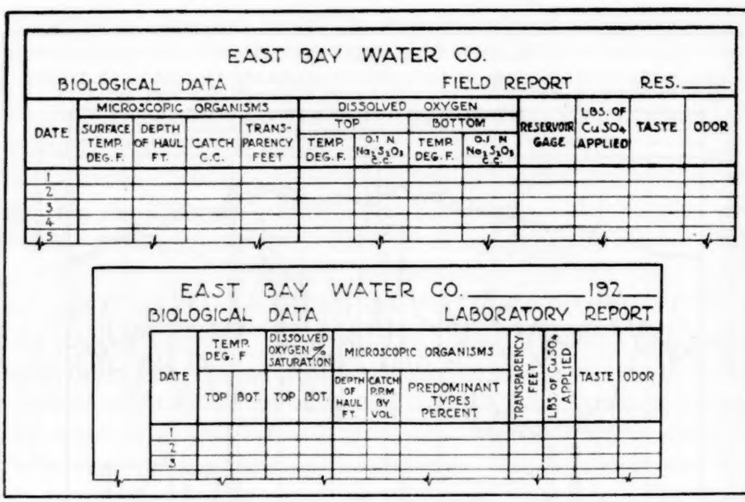

FIG. 2

A few trials with two nets in our own laboratory indicated that velocity of haul and the ratio of net surface to area of circle are of the greatest importance in fixing the net factor. A net having a ratio of 10 to 1 gave double the catch of a net having a ratio of 5 to 1. Obviously these two variables, together with the mesh size or percentage of free opening, determine the pressure which causes the deflection of the water. The fact that a net factor is necessary if accurate estimations are to be made is not a serious objection. If standard procedures are followed, the variables are either eliminated or reduced to negligible proportions.

A plankton net of the mesh size commonly used is not capable of catching certain small forms of plankton. For this reason the term

"net plankton" is sometimes used to indicate that the smaller forms, or nannoplankton, are not included. An examination of a well shrunk net used in our laboratory showed a mesh size of 56.4 x 56.4 microns. There were 4900 meshes to the square centimeter, equivalent to 15.5 per cent of free opening. Fortunately for the water analyst, most of the algal forms in which he is interested are included in the so-called "net plankton." Whipple publishes a list of 22 organisms which have been known to cause tastes and odors in water supplies. Of these, there are only two forms, Cyclotella and Mallamonas, that might escape detection by the net method on account of their small size.

Small plankton, less than 25 microns in size, have received but scant attention, except from a few biologists. They apparently do not cause typical algal tastes and odors in water supplies. Their wide occurrence, however, is well known and has been reported upon, notably byLohmann (9). Some of them impart a distinct cloudiness to the water.

During the past two years the writer, in connection with the examination of certain distributing reservoirs of the East Bay Water Company in California, has used transparency tests for the purpose of setting the time for copper sulphate treatment. The method employed is very crude but exceedingly simple and effective. A white enameled iron plate 8 inches in diameter attached to a graduated cord is dropped into the water and the depth at which it disappears from sight is recorded. At times the plate may be visible 40 or more feet under the surface while at other times it may disappear at a depth of 2 or 3 feet. At such times, if the reservoir is dosed heavily with copper sulphate (the nannoplankton seem to require more copper than the larger net plankton) the dead algae coagulate and float to the surface. The plate readings immediately show the effect in greater transparency. Our experience indicates that the transparency plate test is a valuable adjunct to the plankton net, particularly in connection with clear waters of distributing reservoirs.

Modifications of the Sedgwick rafter and the net methods for the estimation of plankton are in use in many laboratories. In the Sedgwick rafter method, for example, it is the practice in some laboratories to filter the sample through a hard-surfaced filter paper. Kofoid (10), a number of years ago, reported that the sand filter captures from 40 to 65 per cent of the organisms, whereas a good

filter paper will yield from 75 to 85 per cent. The values were based on results with a Berkfeld filter, which of course should yield a 100 per cent recovery. He reported that Berkfeld filters offered the most effective method for the collection of the plankton escaping the silk net. There are now on the market a number of earthenware filters which should be studied to determine their effectiveness for this work.

At the University of Wisconsin, the Forest Continuous Centrifuge has been developed for the purpose of concentrating plankton. A few trial runs in our laboratory indicate that the method possesses certain advantages and is a valuable accessory. It does not, however, seem to be well suited for use in connection with a standard procedure. The errors are selective, and fragile types are disintegrated.

In conclusion, the writer ventures to suggest that in the selection of standard procedures for the examination of water for microscopic organisms due consideration should be given to the fact that optional methods may not be only highly desirable, but actually necessary, if adequate information is to be obtained. In the present discussion one method is favored for its effectiveness in yielding a greater variety of organisms, the other because it provides for simpler and more effective sampling and enumeration. The one is more particularly a laboratory, the other a field, method. The problems of a particular water supply may require either or both procedures.

The writer wishes to acknowledge the coöperation extended by the East Bay Water Company of Oakland, California, in the prosecution of these studies. In 1907, Professor Charles A. Kofoid, one of the pioneers in the study of algal problems in water supplies, began a systematic investigation of the several reservoirs owned by this company. Unfortunately, the work had to be abandoned after a few months. Five years ago the work was again started under the supervision of the writer. Mr. Joseph De Costa, Assistant Sanitary Engineer for this company, is in direct charge of the work.

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THE DECOLORIZATION OF SOFT, COLORED WATERS[1]

By Robert Spurr Weston[2]

This is an account of certain detached experiences in treating soft, colored waters in laboratory and in practice. It is not a detailed, theoretical discussion of the subject, but a selection of certain observations and records from the experience of the writer and others.

NATURE OF COLOR

The older conception of color[3] was that it comprised matters in true solution which were revealed by transmitted light, contrasted with matters in suspension which were revealed by reflected light.

With the development of physical chemistry, the presence of color was explained as being due largely to electrically charged colloidal particles or "suspensoids," as is the current conception. This conception does not include all coloring matter, some of which may be due to colloidal "emulsoids," of which vegetable albumen is typical. Furthermore, it does not yet include certain colored organic compounds and neutral salts in true solution, although the time may come when all matters in water will be classified physically by the sizes of their particles, and not by the terms "dissolved" and "suspended," "non-colloid" and "colloid."

Those interested in water purification are chiefly concerned with coloring matter in the colloidal form, which carries an electro-static charge, either negative or positive, and varying with the water. For the most part, one is concerned with negatively charged particles, which, as is well known, are precipitated by the positively charged Al''' and Fe''' ions.

To discuss the laws of the migration of ions towards electrodes (called kataphoresis) as affecting the removal of color from water, is beyond the scope of this paper, and one is referred to the well

[1] Presented before the Water Purification Division, Chicago Convention, June 9, 1927.

[2] Of Weston & Sampson, Consulting Engineers, Boston.

[3] Decolorization of Water,—Discussion by Whipple, Hazen and others, Trans. A. S. C. E., vol. 46, 1901.

known work of Thorndike Saville[4] for fundamental principles and a description of the experiments upon which they are based. Suffice it to state that negatively charged particles are attracted to and are precipitated by positively charged ions, and vice versa. Also, the reaction and hydrogen ion concentration of the water, as well as the presence of iron and manganese in the coloring compound, greatly influence color removal by any process.

METHODS OF COLOR REMOVAL

One of the earliest observations was that the Mississippi River water, when strained through a porcelain filter, was largely decolorized. This phenomenon is explained as due to the mutual precipitation of colloidal suspensions of color and clay which bear opposite charges, respectively. Removal is rarely complete, and this may be because some of the color bears the same charge as the clay, and is therefore not precipitated, or because of color which remains in the liquid after the absorptive action of the surfaces of the clay particles has reached an equilibrium.

STORAGE

Storage has long been an effective method of color removal. Houston[5] states that from 2.9 to 17 per cent of color is removed from the New River water in as short a period as fifteen hours, but whether or not his determinations were made on samples which were filtered through paper, the standard American method, he does not state. Large lakes with high storage ratios[6] may effect a practically complete removal of color, although it is rare to find a perfectly colorless surface water, excepting in lakes like Superior and Michigan.

The average colors of the two feeders of Silver Lake (the source of supply for Brockton, Mass.) are 100 and 196 p.p.m., respectively. The color of the water pumped from the lake averages 9. This lake has a storage ratio[6] of over 4.

New, and especially new unstripped reservoirs, require from six to ten or more years to become normalized as to color reduction. In this connection it is interesting to compare the colors of the Nepaug

[4] Nature of Color in Water, Jour. N. E. W. W. A., vol. 31, 78 et seq.

[5] Studies in Water Supply, pp. 52.

[6] Storage ratio equals $\dfrac{\text{Capacity}}{\text{Mean Annual Runoff}}$.

Reservoir water supplying Hartford, Connecticut,[7] as predicted by the late F. P. Stearns and the writer, and as observed by the Chief Engineer, C. M. Saville, in practice. These are as follows:

Colors of Nepaug reservoir water

YEAR	PREDICTED BY		OBSERVED BY C. M. SAVILLE
	F. P. Stearns	R. S. Weston	
	p. p. m.	*p. p. m.*	*p. p. m.*
1917	38	26	31
1918	36	30	40
1919	30	24	38
1920	27	23	28
1921	25	22	24
1922	24	21	26
1923	16	20	23
1924		20	23
1925		19	24
1926			21

In the northeastern states the degree of color removal is a function of the period of storage. Figure 1 exhibits data from various sources.

In these, the percentage reduction is measured by comparing the influent with the effluent, a method which takes no account of decolorization by dilution of the contents of the reservoir with colorless ground water, or of relative positions of outlet and inlets.

In figure 1 a parabolic curve of estimated mean values for the Upper Passaic River has been drawn. From this curve the following values may be derived:

Estimated average removal of color by storage in reservoirs in the northeastern United States

MEAN STORAGE PERIOD	STORAGE RATIO FOR A MEAN ANNUAL RUNOFF OF 1 MGM. PER SQUARE MILE	REDUCTION IN COLOR
days		*per cent*
50	0.14	19
100	0.27	27
250	0.55	38
300	0.82	46
365	1.00	52

[7] C. M. Saville, Engineering News-Record, vol. 89.

Iron is an important factor in purification by storage, as is well known. The highly colored compound formed of iron and organic matter is quite stable in aerated water, and is bleached but slowly by sunlight. During the stagnant periods when fermentation of

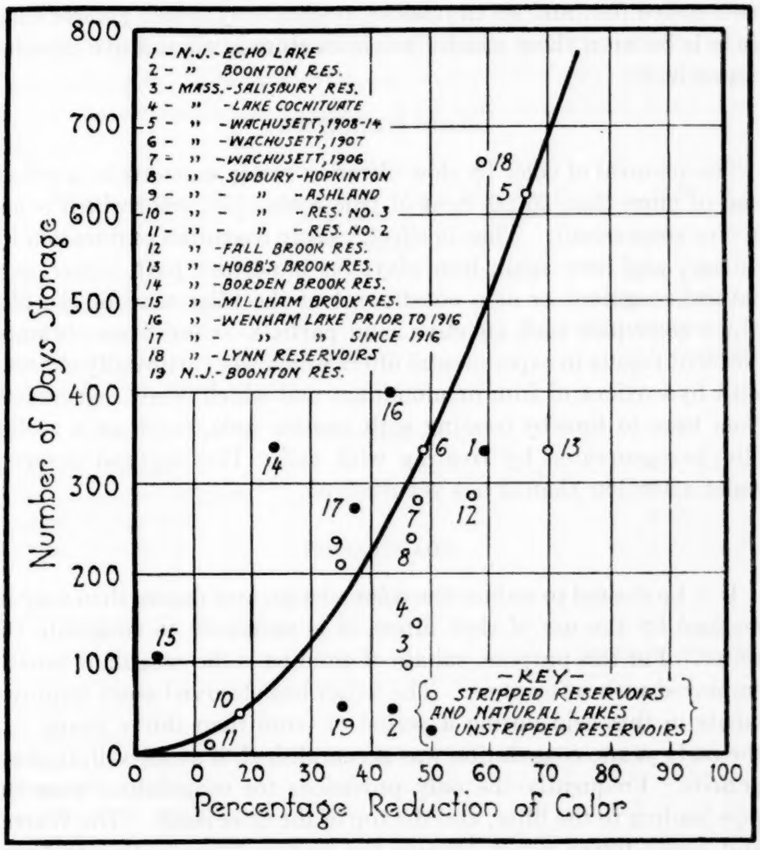

FIG. 1. REDUCTION OF COLOR BY RESERVOIR STORAGE

organic matter takes place in the stagnant zone of a reservoir, this compound of iron and organic matter is decomposed. In the absence of oxygen the organic matter is released, while the iron is reduced to a greater or lesser degree. With the semi-annual overturns, the iron is brought to the surface and re-aerated. It then acts as a coagu-

lant for the coloring matter. The coagulated matter settles to the bottom, there to decompose.

These phenomena explain the desirability of storing water through at least one of the overturns, that is, for a period of at least six months. There is a great difference in character between waters which have been stored four and seven months, respectively, much greater than there is between those which have been stored two and five months, respectively.

SLOW FILTRATION

The removal of color by slow filtration rarely amounts to a reduction of more than 25 per cent of true color, (i.e., color which is not in true suspension). This, in effect, closely resembles purification by storage, and here again iron plays an important part, either as a natural coagulant or as a constituent of the filter sand or the film which surrounds each effective sand particle. Clark[8] has obtained excellent results in experimental filters which were artificially charged with hydroxides of iron or aluminum and which were regenerated from time to time by treating with caustic soda, much as a zeolite filter is regenerated by treating with salt. This method deserves wider attention than it has yet received.

COAGULATION

If it be desired to reduce the color to a greater degree than may be reached by the use of slow filters, it is necessary to coagulate the water. For this purpose, sulfate of alumina is the coagulant usually employed with soft waters. The writer has observed great improvements in this field during a period of more than thirty years. In the early years, coagulation was accomplished, if at all well, in short periods. Frequently the only provisions for coagulation were the pipe leading to the filter, and the top of the filter itself. The Warren and Jewell filters, which became the leading filters in the 90's, provided for periods of coagulation of sixty-one and thirty-six minutes, respectively.

Some of these older filters gave excellent results. For a year, beginning July, 1914, the plant of the Biddeford and Saco Water Company, supplied from the Saco River, was carefully observed. This water ordinarily has a color of from 30 to 40 p.p.m., is quite free

[8] N. E. W. W. A. Jour., vol. 36, 3, 385, September, 1922.

from suspended matter, and has an average alkalinity of 3.5 p.p.m. It is coagulated by the addition of less than 1 grain of alum per gallon. The period of coagulation in this plant is less than one hour, and water flows through the basin at velocities as high as 4.5 feet per minute, but even with this short period and these high velocities, (less than 0.1 foot per second), the color was reduced, after filtration through Warren filters, to less than 1 p.p.m., and the alkalinity to about 0.5 p.p.m. The effluent is unusually free from mineral and organic matter and no complaints of its corrosive action have been made.

TABLE 1

Results of operation of 37th Street filters, Norfolk, Virginia, 1926

Volumes

Capacity of plant	12 m.g.d.
Water treated—average	5.989 m.g.d.
Period of service of filters	18.9 to 29.1 hours
Nominal capacity of coagulating basin	4 hours' flow
Per cent of wash water	2.7

Chemicals

Sulfate of Alumina	26.9 p.p.m.
Hydrated lime, to effluent	7.15 p.p.m.
Chlorine, to raw water	0.88 p.p.m.
Chlorine, to effluent	0.13 p.p.m.

Analytical results

	RAW	C. B. EFFLUENT	FILTER EFFLUENT
Average turbidity	18.1		
Average color	50.9	17.3	6.6
Average alkalinity	35.5	24.2	34.1
Average pH value	7.1		7.9
Average carbon dioxide	6.3	8.0	1.75
Average iron	0.87		0.29

The old plant at Norfolk, Virginia, as is well known, was similar, yet the results from it were unsatisfactory from every standpoint and did not become satisfactory until after a long series of experiments and trials in practice, ending finally in a method which embodied pre-chlorination, aeration after coagulation, and a long period of storage before filtration. Careful adjustment of the reaction of the water prevented corrosion.

During 1926 the new 37th Street purification plant, treating water from Lake Prince, was operated with the results shown in table 1, which were kindly furnished by Wm. W. Watkins, C. E., Superintendent of Filtration.

The Norfolk plant represents a good example of current practice with waters of this type, which practice has evolved out of experiences with waters in all of the Atlantic States, among which will be recalled the work of Catlett[9] and Norcom[10] at Wilmington, N. C., and the interesting experiences at West Palm Beach, Charleston, Avalon, (Md.), Newport News, Virginia Beach, (Va.), Champaign, (Ill.), Exeter, (N. H.), Oakland, (Cal.), and elsewhere. Some details are of interest.

RANGE IN DOSE OF CHEMICALS

The Swift River, in Maine, is a normal stream, soft, colored and clear. It discharges into the Androscoggin River, which is polluted and is soft, colored and slightly turbid. The water of the Swift River requires only 10 p.p.m. of alum with a short period of mixing and coagulation to remove a color of 40 almost completely, while the same color in the Androscoggin River water may not be reduced to below 10, excepting after pre-chlorination followed by three weeks' storage, and then by treatment with nearly 100 p.p.m. of alum, a course which is obviously too costly to follow in practice.

The difference between the two waters is due to sulfite pulp liquor in the Androscoggin River, and in this connection the experience at Watertown, New York, where there is a lesser degree of like pollution, is interesting and, while generally known, is well worth recalling.

Here, Mr. Jennings found that a color of 80 p.p.m., due to ordinary vegetable matter, could be reduced to 5 by the addition of 66 p.p.m. of sulfate of alumina, while the same degree of color due to sulfite-pulp liquor was not reduced appreciably by 175 p.p.m., of the same coagulating chemical. The original municipal plant, which was not working efficiently, although a good example of ordinary construction, was improved by building a coagulating basin storing approximately two weeks' flow; by adding chemicals to the water entering it; also, if necessary, to the basin storing four hours' flow, which was

[9] Catlett, G. F., Eng. Record, June 3, 1916.

[10] Norcom, Geo. D., Jour. A. W. W. A., "Purification of Colored Water at Wilmington, N. C.," 96 seq. and 833 seq., vol. 11, 1924.

attached to the original purification plant and which had proved to be utterly inadequate; and by aeration.

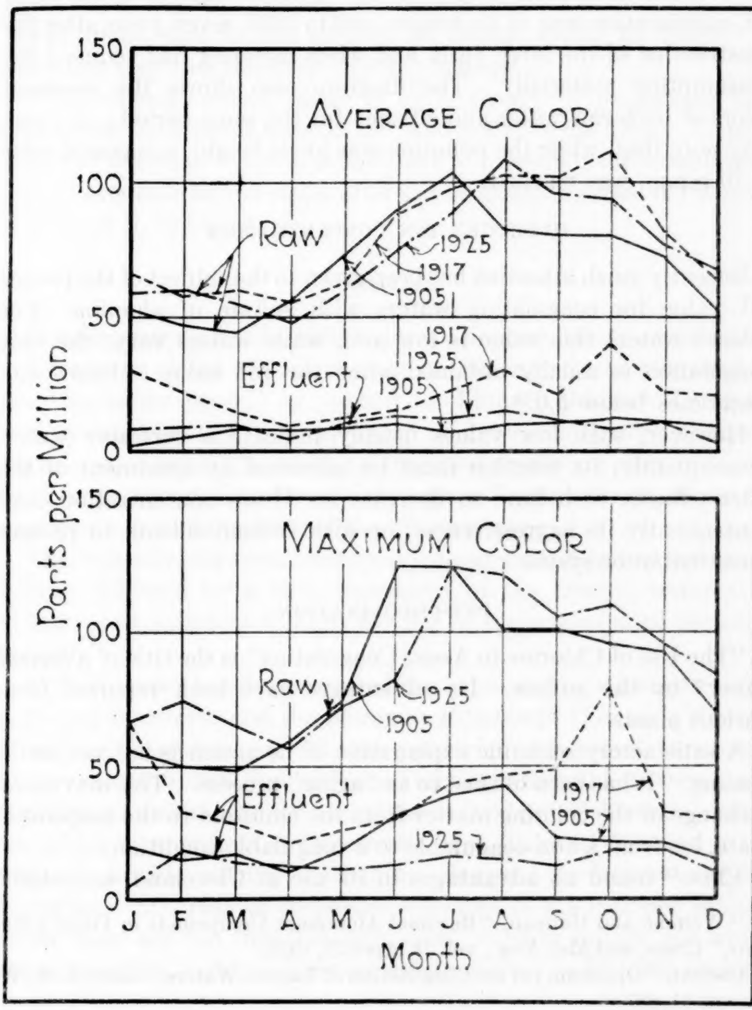

Fig. 2. Color Changes, Water Supply, Watertown, N. Y.

Figure 2, prepared from figures kindly furnished by City Manager Ackerman and Mr. Jennings, illustrates the experience at Watertown. It shows the average color of the raw water and effluent in 1905,

when the consumption of water in proportion to the capacity of the filter plant was low and when the degree of pollution was not so great; in 1917, just before the large coagulating basin was built, and when the consumption was at its height; and in 1925, seven years after the construction of the large basin and when metering had reduced the consumption materially. The diagram also shows the maximal colors of both raw water and effluent for the same periods, and one may note that, while the pollution was at its height, a maximal color of 79 p.p.m. was reached.

HYDROGEN ION CONCENTRATION

Recently much attention has been given to the subject of the proper pH value for coagulating waters with sulfate of alumina. For colored waters this value is low and, while waters vary, the best coagulation is usually obtained when the pH value is below 6.0, sometimes below 5.0.[11]

However, such low values usually indicate a corrosive water. Consequently, its reaction must be corrected by treatment of the filter effluent with lime to decrease its H-ion concentration, and consequently its aggressiveness, or with sodium silicate to protect the distribution system.

PRE-CHLORINATION

"The Use of Chlorine to Assist Coagulation" is the title of a former paper[12] by the author. Its advantages have been reported from various plants.

A satisfactory scientific explanation of its action is not yet forthcoming. It has been likened to an "aging" process. This may mean a change of the coloring matter from the emulsoid to the suspensoid state, i.e. from a non-coagulable to a coagulable condition.

Ellms[13] found no advantages in its use at Cleveland, and stated

[11] Wolman and Hannan, "Residual Aluminum Compounds in Filter Effluents," Chem. and Met. Eng., vol. 24, April 27, 1921.

Catlett, "Optimum pH for Coagulation of Various Waters," Jour. A. W. W. A., vol. 11, 887.

Baylis, "Use of Acids with Alum in Water Purification and Importance of pH," Jour. A. W. W. A., vol. 10, 365.

Norcom, loc. cit.

[12] This Journal, vol. 11, p. 446, 1924. Also Water Works, vol. 59, June, 1923.

[13] Second Annual Report, Ohio Conference on Water Purification, 1922.

that he believed it would exert a destructive action upon filtering films. However, Norman J. Howard,[14] working at Toronto with the same water, but with drifting sand filters in place of ordinary rapid filters, found that its use effected an annual saving of $48,000 in operating cost, due chiefly to a saving in alum.

With colored waters, there is little danger of overdosing and destroying the filtering films on the sand grains of the filter. Usually a dose of less than 1 p.p.m. is sufficient to prepare it for coagulation, and its existence in free states after any reasonable period of coagulation is not to be feared.

MIXING

Good mixing of chemical and water is a pre-requisite to coagulation, and for large plants nothing exceeds in efficiency the employment of the "hydraulic jump," as studied by Ellms,[15] although Langelier prefers rapid mixing tanks arranged in series, and baffled channels are in common use. In smaller plants good results are often obtained by passing chemical and water through a Venturi throat, a centrifugal pump or a mixing tank of the "Vortex" type.

Theoretically, the ideal treatment for water consists first in violent mixing, followed by a slow movement of the treated water at a velocity just sufficient to keep the floc in suspension until perfectly formed.

C. P. Hoover[16] has demonstrated the value of slow stirring in water softening reactions, and the plants at Pittsburgh (Penna.), Newark (Ohio), and elsewhere, embody this principle. Langelier's experience at Sacramento shows that prolonged mixing is desirable in the case of turbid river waters, and the new plant at Oakland, California[17] makes use of his arrangement of four tanks, each 21 by 21 feet and fitted with a variable stirring mechanism designed to impart varying velocities. Mr. Hoover employed velocities of 0.6 foot per second. Even these are too high for soft, clear, colored waters, for which velocities of 0.1 to 0.3 foot per second are best. In fact, the thought

[14] This Journal, vol. 9, 606, 1922. Also Canadian Engineer, February 26, 1924.

[15] This JOURNAL, vol. 17, 1, January, 1927.

[16] This JOURNAL, vol. 9, 582, et seq., May, 1924.

[17] New 12-M. G. D. Water Purification Plant for Oakland, Eng. News-Rec., vol. 98, 857 (1927).

of rapid motion and its cost has delayed the introduction of mechanical stirring as an aid to coagulation.

At the Springdale plant of the American Glue Company, a Dorr agitator was used to stir the treated water prior to its passage through basins as high as 3 feet per second. This device has the merit of aerating the treated water, and while it has been borrowed from ore-treating, it has been an effective device for treating water.

The usual agitator is a tank with slowly rotating paddles. In smaller plants a circular tank with tangential inlet may be used successfully, as at Lawrence, Mass.

The chief advantages of tanks with mechanical stirring as compared with baffled channels and larger basins are the frequent saving in construction cost, the greater flexibility in operation at various rates, the saving of head, and greater accessibility for cleaning. The cost of power for slow stirring is small.

The gains in efficiency have been satisfactory in many, but not in all cases. One water from Northern Maine may be decolorized much better after proper dosage followed by stirring for thirty minutes, and by two hours' storage in a coagulating basin, than after a six-hour period of storage in the basin with no stirring beyond the initial rapid mixing of chemical and water. Furthermore, the use of stirring effects a reduction of 10 p.p.m. of sulfate of alumina. Similar, but not so marked advantages due to slow stirring, occur with certain waters in Rhode Island and New Jersey.

RE-SOLUTION OF COLOR

It has long been known that coagulating basins must be cleaned not only to remove the accumulation of sludge, but also to prevent the re-solution of the sludge by the water. This effect is probably due to the reduction in surface area of flocs due to their consolidation as sludge in the bottom of the basin. One advantage of slow stirring is that this consolidation is prevented and the coagulating basins, which follow slow stirring, may be made so small that often they may be cleaned mechanically, thus avoiding an accumulation of sludge to affect the color of the water and reduce the effective capacity of the basins.

SUMMARY

The best coagulation of color in water seems to be obtained when the Al''' ions combine directly with and precipitate the color particles.

When decolorization must be brought about by the absorptive action of a large mass of hydrate upon the coloring matter, the dose of chemicals is large, and the cost of treatment high.

Preliminary treatment with chlorine seems to obviate or minimize the necessity for the second reaction.

The adjustment of reaction, mixing, stirring and time are all important factors.

Experience has taught purification-plant managers the proper treatment for practically all naturally colored waters. It has also taught them the treatment for waters polluted with certain artificially colored wastes, even those polluted with small amounts of sulfite pulp or bleaching kier liquors. However, no economical method is known for waters which are strongly polluted with these liquors or with certain tarry or saccharine coloring matters. These latter are apparently sub-colloidal and require some biological process either as a preliminary to or as a necessary part of coagulation. Perhaps these bodies must be transformed from a more dispersed to a less dispersed condition before they can be purified by coagulation and filtration.

DISCUSSION OF MANUAL OF WATER WORKS PRACTICE[1]

CHAPTERS 2, 4 AND 5

MR. ALLEN HAZEN:[2] Working under a committee of editors and having many conferences about the subject matter of the chapters that I wrote, I was between two millstones. In the first place, the subject must be completely covered. That was insisted on. In the second place, it must not exceed so many pages. That also was insisted on. It was a matter of selecting, therefore, what would be most generally useful in that field that could be said within the limits of the pages assigned.

And this method necessarily means that a great many useful and interesting matters are excluded. I know this in another way. I have repeatedly looked in the Manual to see what was said about some matter that I wanted to know about. It is common to find that the subject under inquiry is not treated by the Manual at all. This condition is probably inevitable because of the nature of the business.

The water works business is an art. It is a tremendously complicated art. The things that go into the complete knowledge of it are beyond what any one person could possibly have in his head. The information about how things are done and how they ought to be done and how they can be done for the most part is passed along from man to man. Men who were proficient in doing certain parts of the work teach other men to do those things and the art is transmitted from man to man and not by the way of water works literature. Only a relatively small part of all this information is ever reduced to black and white and printed. If it could be all printed nobody would read it because there is so much of it. The problem is to pick out the things that are of general interest and that will be helpful and that do not go too far into the details of one man's work that are not of interest to others.

[1] Discussion presented before the New York Section meeting, December 28, 1927.

[2] Consulting Engineer, New York, N. Y.

The chapters that I am asked to discuss today cover in a general way the collection, storage and quality of water supplies. There has been perhaps more change in our ideas in regard to quality than in any other part of the work. Thirty years ago the qualities of waters supplied in American cities were very far below present standards.

The first great problem for the water works people of that time was to bring the quality up to a point where the waters would be healthy and not cause serious disease. That has been the great work of the water works men in the last generation in the United States, and it has been done pretty thoroughly. Years ago hundreds and thousands of people died each year from drinking polluted water. Now it is exceptional to find sickness and death that can be traced to water supply. This advance is very gratifying, but it is not enough. The ideal always recedes.

I want to quote a sentence that was written by my late partner, George C. Whipple, on this subject in the first edition of his book on microörganisms, of which a new edition has just come out. He says:

> The demand for clean water is growing. Popular standards of purity are rising. Our cities need water of such quality that the people not only can drink it with safety but can drink it with pleasure. "Safety first" is as good a motto for the water supply service as it is for the railroad service, but safe water that is not also clean loses psychologically much of its value.

We have made progress in producing water that can be drunk with pleasure, but there is still a long way to go. Spring water is most agreeable at a temperature of about 50° and no one would think of icing it. Such water is pleasanter to drink and is much healthier than ice water. In our hotels throughout the United States the water is commonly iced. It is iced, I think, because, as a general proposition, the waters of our public supplies do not taste well at the temperature at which spring water is best. It is necessary to ice them to make them palatable. There are many exceptions, but the ice water habit is common, and we must admit that many of our waters are not agreeable without ice.

We have something to do to bring water uniformly to a quality where people can drink it with pleasure and without icing and I hope that the next edition of the Manual will go somewhat more deeply into the means of doing it.

CHAPTER 3

MR. C. A. HOLMQUIST:[3] There are two features, one of which is mentioned in the chapter, that I would like to emphasize because I think they are of far-reaching importance to water works authorities. One is the coöperative agreements that have been reached between certain state health departments which tend to protect from pollution and conserve our streams. That was started, as the book says, in 1922, between Pennsylvania and New Jersey. Later in 1925, a similar agreement was drawn up between the State Health Departments of New York and Pennsylvania and we in New York have already felt the benefits of that agreement. The other is the agreement which resulted from a conference called by the Surgeon General in Washington in 1924, following which a meeting was had in Pittsburgh between the health officials of the states on the Ohio River basin and some fifty representatives of industrial concerns, nearly all of which were interested in steel manufacture and by-product coke oven operations, primarily for the elimination of the discharge of phenol waste into streams which had made some of the water supplies in Pennsylvania and Ohio and West Virginia almost undrinkable.

Following that conference an agreement was reached between practically all of the states on the Ohio River basin, including New York. This agreement, which was entered into less than three years ago, has resulted already in the elimination of a discharge of phenol waste from the by-products of coke ovens from 20 out of 21 plants on the Ohio River basin with a corresponding elimination of taste-producing qualities in the water supplies. These improvements have been possible only by the splendid coöperation which the health officials have had from the large manufacturers. I think these concerns realized that it would not be a wise policy to oppose the reasonable wishes of the State Health Departments of all of the states on the Ohio River basin.

In New York State we had three coke plants which produced objectionable tastes in three different water supplies. In all three cases the condition has been almost entirely, if not entirely eliminated. In one case the wastes are used for quenching coke. In another case it is absorbed in benzol, eliminating 95 per cent or more of the phenol from the ammonium still liquor. In another case, after three months experiments and tests, ammonium still liquor is now being

[3] Director, Division of Sanitation, State Department of Health, Albany, N. Y.

discharged in a sewer tributary to the sewage disposal plant of a large city and it has eliminated the objectionable condition that formerly was created from tastes and odors in one of the large water supplies of the state.

The other is a movement that has been started by various state health departments in coöperating with industry in solving their waste disposal problems. It has heretofore been customary for a state health commissioner to issue an order on an industry requiring that industry to abate the nuisance created by the pollution due to its waste without knowing how it could be best and most economically corrected. The manufacturer in most cases knew relatively little about how the problem could be handled. The result has been that many disposal plants for the treatment of industrial waste have been installed in this country which have not produced the results expected and the money has been largely wasted in many cases.

Various departments of health have gone to industries as a whole and induced them to study the problem as an industry. Such work is being done in Pennsylvania with the leather and paper industry and it has been done in Ohio with the canning and milk industry. Last year we took up with the Canners Association of New York State the problem of studying the disposal of cannery waste. At our recommendation a full-sized experimental plant was installed at the factory of the New York Canners at Albion, which is one of the biggest canning factories in the United States. Under a consulting engineer experimental work was carried out on the treatment of a certain type of waste resulting from the canning of their products, including tomatoes and beans. Unfortunately the plant was not completed early enough to enable tests to be made on the wastes from canning of peas, which is one of the most objectionable wastes in the canning industry. The plant was paid for by the New York Canners. The consulting engineer and the cost of carrying on the experimental work was paid for by the New York State Canners Association, and the National Canners Association furnished a chemist to make the tests designated or desired by the consulting engineer.

Work has been done in Ohio, in Michigan, Wisconsin and in Maryland. We realized that, if this work was to be continued on the statewide basis, it would mean a duplication of effort. In order to avoid that, we have arranged for a meeting in Washington with the National Canners Association and we shall try to put this work on a national basis so as better to coördinate it.

We are also working now with the milk industry. We feel that in handling it in this way one industry can be taken up at a time. We shall finally be able to go to all of these different industries and be able to indicate how they can probably best care for their waste. Of course, the data obtained from experiments represent basic information which will have to be applied by engineers experienced in the treatment of waste.

The phenol waste problem could not have been handled in a great many years by the old method. We feel by this coöperative method we have made as much progress in the last three years as has been done probably in the last twenty years.

In New York State, particularly since about three-quarters of the population is supplied with water from surface sources, our Commissioner of Health realizes that if the water supplies of this and future generations of this state are to be conserved, it is necessary for him to stop, so far as he can, any further pollution of surface waters and to eliminate the existing pollutions as far and as fast as he can.

CHAPTER 5

MR. E. B. PHELPS:[4] In defining the quality of water one is reminded somewhat of the old parlor trick of defining a cow. Most of us know what a cow is and recognize one, if we are sober, but to attempt to define a cow is rather humorous. So it seems to be with the definition of a water of good quality. We all have in mind what constitutes water of good quality, but in any attempt at defining such water we find ourselves at once in the most embarassing situation.

In the first place, quality is purely relative in the sense that it relates to the use of the water. For purely commercial purposes, typhoid organisms would not constitute a serious deterioration in quality. Of course, that would be very serious in regard to waters for domestic use. In the second place, quality is relative in the sense that no matter how well we might agree upon an ideal water, water of ideal qualities, we are always faced with the question of expediency as to how far we are justified in going to produce a water coming up to any such standard specification. Mr. Hazen has very well put the matter when he says our ideals recede. As we progress we can always see opportunities for further progress.

Quality of water as it is handled in the Manual follows, by actual

[4] Professor of Sanitary Science, Columbia University, New York, N. Y.

quotation, the report of the Committee of the Treasury Department upon that subject and deals with many of the minor matters of color, turbidity, hardness, iron and other metals, and then, of course, with the all-important question, from the hygienic standpoint, bacteria.

I would just like to touch in passing upon one of these minor matters and that is the limitation placed upon certain metals, particularly copper. The value for copper is 0.2 part per million; lead, 0.1; and zinc, 5.0. For lead and zinc there probably is good authority but there seems to be very little evidence as to the harmfulness of copper, and with the increasing use of copper piping for household piping, I think that figure may very well be reconsidered.

My colleague, Dr. Flinn, is engaged at the present time in a study of the physiological effect of copper upon animals and I feel that one of the outcomes of that study will be to reinforce an opinion which has been held by many for a great many years on the relative harmlessness of copper in considerably larger amounts than are allowed by this standard.

When we approach the subject of hygienic quality from the standpoint of communicable disease we still find that our standards are indirect, most unsatisfactory. Just as it is difficult to define water quality in any respect, it becomes exceedingly difficult to define the quality of water in the terms of hygienic standards. I think we ought to recognize at the start that standards do not make water. Good water supplies make standards. The committee that drew up the Treasury standards did not attack the problem de novo from the point of view of standards. They looked about them and inquired what are the satisfactory water supplies of the country and what qualities have they. I can say frankly they put down the quality of water which they regarded as the standard on the basis of satisfactory existing supplies.

Typhoid fever is the major water disease and Mr. Hazen told us how that had been reduced. That reduction can only be maintained by constant supervision, and it is possible at any time by relaxing that vigilance even in the operation of a well-designed, well-built plant, to undo all of the good that has been done. To attack typhoid, the older chemists went after sewage in general. They said, "We cannot define typhoid as such and so we will define our water in terms of sewage." They tied everything up to albuminoid ammonia, those interesting chemical terms. We found that was not very specific; that there were other kinds of pollution. We found the pollution of

normal upland waters, which had albuminoid ammonia figures about the same as those found in waters containing sewage.

Then the bacteriologists came to the front and for a good many years we have had bacteriological rather than chemical standards, and there also there has been much change. We had to depart from the total number of bacteria which was originally taken as an indication of pollution for the same reason. There are many kinds of water which do show high normal bacteria, perfectly harmless bacteria, of the soil and woods, but at the time of the spring freshets they show up in the water supplies in such numbers that any standards for the elimination of sewage would be exceeded by these perfectly normal bacteria.

Then they discovered B. coli, and they decided that here at last was the sewage organism par excellence. Again their hopes were blighted because the so-called sewage organism or his very near relative occurs under natural conditions and occurs, even the organism itself, in the excreta of domestic and wild animals, so even B. coli is not a real test of sewage pollution.

That is about as far as we have gotten. Bacteriologists are working on the further differentiation of these organisms, but our standard test today, by this circuitous route, has gotten down to a simple definition of a satisfactory water supply in terms of B. coli. Now we get into another difficulty. B. coli themselves are not actually counted the way the bacteria were but they are obtained by a series of dilutions. That is, the water is diluted in smaller and smaller quantities until a quantity is found which does not contain the organism. Any who are mathematically inclined will realize that interpretation in terms of actual number of B. coli to the cubic centimeter is a rather involved mathematical process. In fact, it is so involved that many ponderous works have been writen on the interpretation of B. coli results and as far as I can determine the experts are just as much at sea as ever on the exact meaning of the B. coli figures. But we have a fairly satisfactory result and as I said a while ago that result has not been obtained by way of standards, but by finding out what satisfactory water supplies are giving and then setting up of standards to match that result.

The real test, after all, of a water supply is the health figure, typhoid fever statistics, the epidemic statistics of communities, and there I think we have much to congratulate ourselves upon. Typhoid fever has certainly been reduced to a very low point from

whatever cause. I think perhaps water works people are inclined to take too much credit for this reduction and have failed to observe that in many of our cities, like Boston, where little has been done in the last fifteen or twenty years to improve the quality of the water, there has been the same downward sweep in the typhoid fever curve that has occurred throughout the country at large. Practically the same thing might be said of New York. In spite of the additional precautions that are being taken, one searches almost in vain for any evidence that there ever was very much typhoid fever caused by New York's water supply. One might reason logically that the precautionary methods, good as they are and probably as preventive as they are of sudden small epidemics, from any sudden, unsuspected source of pollution, are probably not doing very much and have not been very largely responsible for the downward sweep of the typhoid fever curve in New York City, which, like that of Boston and the rest of the country, has been continuous and progressive for the last twenty years.

I suppose the purpose of all of this is for the amendment or discussion of the actual facts in the book. I have very little to say on that point. It can hardly be improved. I fully agree with Mr. Hazen that as we go on we want higher and higher ideals. The last Treasury standard is just twice as stringent as the previous one. I remember the outburst of indignation that came from the water works people at that first standard. They said, "We can't possibly do it." They have done it and now that standard has been doubled and there was not half as much indignation shown at the issuance of the last standard. Apparently the water supplies of the country are meeting the new Treasury standard without difficulty and so we can look forward to increasing our ideals and increasing our approach to the ideals, eliminating the color and the hardness and the odors and making the water pleasurable to drink as well as healthful.

There is one interesting point in connection with what Mr. Holmquist said, and that is that water pollution and water purification and sewage disposal are coming to a meeting place pretty soon. The actual load of pollution in many of the Western rivers in particular, like the Ohio River, is rapidly gaining over the advances in the water purification art, which means that eventually we have got to attack the problem from the other side. One of the most interesting matters as to the quality of water today is as to the upper limit we are going to permit of pollution in rivers that have to be used for

drinking water supplies. We are going to reach the place, if we have not already reached it, where water purification cannot take out the sewage bacteria, cannot take out the typhoid because of the extreme load of pollution from city sewage. While we have put that day off, successfully so far, by increasing the efficiency of water works plants, by the development of new processes—of course, the chlorination process today has made much progress—and all of those things which make it easier and cheaper. [illegible] still must not overlook the fact that eventually we are coming [illegible] deadlock where we have to go at stream pollution from the other end.

CHAIRMAN BECK: As I stated before, this meeting is called to discuss the Manual and particularly for constructive criticism. I know that Mr. Fuller and his committee would like to know how many of you have referred to the Manual on any specific problem, and if so, did you find the information you sought? We shall open the first five chapters on collection and quality of water for general discussion. Have any of you referred to the Manual and failed to find what you wanted?

MR. F. T. KEMBLE:[5] I have one little point I should like to bring up. Referring to Mr. Holmquist's statements, I would like to know if there is something we can do to help him. We all know that Mr. Holmquist and the Health Department have accomplished all sorts of things and I think it is up to us to do anything we can to hold up their hands. I would like to ask him what he has in mind whether he would like to have a committee to confer on this matter or whether a resolution from this Association would be of particular assistance to him.

MR. HOLMQUIST:[3] We are planning to draw up legislation to be introduced this winter and we could submit copies of the proposed bills to the organization. We might get a letter ballot later for an expression of opinion backing this bill from the organization itself or its representatives in the various parts of the state.

[5] Secretary, New Rochelle Water Company, New Rochelle, N.Y.

CHAPTERS 6 TO 12 INCLUSIVE

DR. FRANK E. HALE:[6] I wish to pay tribute to the excellence of the material included under "Treatment of Water." The real criticism that I would raise is that in order to keep the Manual within convenient size the text was cut to the extreme limit. I had the privilege and pleasure of reading most of the original material and it included much valuable information which could well have been retained. In fact, if the Manual should be increased to two volumes, the original contributions which were prepared with much labor should be reëxamined. "Treatment of Water" could well be a volume by itself. In preparing for this discussion I have carefully reread the 132 pages of these chapters and as briefly as possible shall suggest possible additions or changes.

To the portion on self-purification might be added some of the specific data and formulae worked out by Streeter and others in the Government work on the Ohio and Illinois rivers.

Under Sedimentation, page 158, is given a table showing time of subsidence of various sized particles of specific gravity 2.65 at 50°F. in pure still water. In this table clay of size 0.0001 mm. is estimated as settling 1 foot in 230 days. In this connection the actual experience of New York City's Water Department last winter may be interesting. Due to heavy rain and washout of clay banks on the Esopus and Schoharie Creeks the water in Ashokan reservoir contained a turbidity of 100 p.p.m. which slowly settled to 5 p.p.m. in about six months, 180 days, at the depth of draft, say 50 feet. Recently we measured some of these fine particles under the microscope and they apparently ranged from 0.001 mm. to 0.0002 mm. in size. They were so small that they exhibited the Brownian movement. Possibly this constant movement helps to keep the fine particles in suspension and may be due to carrying a charge of electricity of like kind so that they constantly repel each other, preventing rapid coagulation and settling. The time experienced for the depth would be that of the average of sizes measured.

Under Digestion of Organic Matter, pages 161–162, might be added a brief statement on the Bacteriophage theory of d'Herelle in which ultra-microscopic forms of life feed on bacteria.

Under Current Practice with Algaecides a few additions and

[6] Director of Laboratories, Department of Water Supply, Gas and Electricity, New York, N. Y.

changes may be made in table 7, a few changes in the text including additional facts under use of chlorine, addition of the fact that copper may not settle in reservoirs, but may be retained in the water and addition of references. Attention should be called to the very valuable and comprehensive information in the latest edition of Whipple's Microscopy of Drinking Water.

The chapter on Chlorination needs revision owing to steady increase in knowledge as shown by Enslow's recently published review of the year 1926, (Jour. Am. W. W. Assoc., volume 18, November, 1927, page 621–640). I would advise omitting much of the fine print on pages 175–176 as to theory of action. The subject is controversial and there is much to be said on both sides. For example, in the last paragraph on page 175 I would reason in just the opposite manner. The statement implies that formation of chloramine by ammonia and bleach proves the action as one of chlorination rather than oxidation. But chloramine only forms in alkaline solution and to my mind is merely a chemical interaction forming ammonium hypochlorite which then loses one molecule of water to form chloramine. Such a reaction would explain why dichloramine and trichloramine apparently are not readily produced. Furthermore, liquid chlorine and ammonia do not usually form chloramine as would be expected from a partial chlorinating action, but produce nitrogen gas. Again in the first paragraph, page 176, where it states that there is no evidence of production of free chlorine from bleach, I would call attention to the odor of chlorine whereas pure hypochlorous acid is stated to have no odor. The collection of chlorine odor in a partly filled bottle of chlorinated water, the ready loss of chlorine strength in dropping dilute solutions through air, the effect of aeration, suggest the presence of a gas in solution in many cases. It seems preferable to assume that the reaction may be either that of oxidation or chlorination depending upon various factors such as acidity, alkalinity, etc.

On page 177, first four lines, concerning the action of chlorine on bacteria, evidence recently published on the action of chlorine on sewage would indicate destruction of amino compounds in the substance of the bacteria.

In the middle of the second paragraph on page 177, loss of chlorine in sludge is given as usually 2 per cent. This is a very low estimate. Losses may run very much higher.

On page 178, third paragraph, Sacramento, California, may be added to the cities using electrolytic chlorine.

On page 178, second paragraph, under heading Chloramine, is the statement that less chlorine is required in the form of chloramine to effect results. A year's practical comparison of bleach and chloramine on Esopus Creek by New York City showed no difference whatever. Clark of Massachusetts also found no difference.

On page 179, fifth line, the words "of Long Island City" should be deleted.

On page 180, second line, it is stated that "color is not changed to any appreciable degree." I have know of instances of 10 to 25 per cent reduction by prechlorination.

Considerable of the material on page 180 should be combined with page 184 due to duplication.

On page 181, second line, under "Tastes and Odors" the words "or hypochlorous acid" are questionable.

In the last paragraph page 181, fifth line, the classification of odor (*a*) is probably mis-stated. I have seen no evidence that the chlorine combines with algae oils to produce odor. Rather chlorine destroys odor by such combination. Moderate dosage of chlorine sets free the odorous oil and the odor cannot be distinguished from that produced by the organism alone.

Also page 181, last three lines, Howard of Toronto, and also Thompson, have recently shown that superchlorination does destroy odors of class (*b*) resulting from chlorine and phenols or cresols. Enslow's recent review contains these data. At the end of this division on Taste and Odor page 182 should be added a statement on "Superchlorination and dechlorination" as practiced by Howard, and the statements under this latter heading on pages 184–185 changed to this location on page 182 with proper modification.

The use of ammonia and chlorine to control odor should be added on page 182.

Under heading Corrosion, pages 182–183, might be added the statement that "chlorine dry fed to cast iron mains has been known to cause serious corrosion in a few weeks even through one inch of metal. It is advisable to avoid such practice."

Under first paragraph of Dosage page 185, the word "completely" should be omitted since absorption of chlorine varies with the dosage.

As to "Simplified Method of Chlorine Control" pages 185–186,

I strongly object to this as the only method described. It seems too crude except for small stations that cannot afford any better. For a well equipped plant the full set of standards is far preferable, since any necessary change of dosage may be made with precision without guess or delay. The determinations are also much more accurate by standard methods.

In the detail on page 186 under paragraph 3 of Procedure, 5 drops of orthotolidin is too little. The amount should be one-half cubic centimeter for 50 cc. of water. The depth of color varies with different amounts of orthotolidin. Under (4) a two-minute contact is too short except with well water. Turbidity even then causes sometimes ten to fifteen minutes for full color development and with surface waters full color may not come for one-half to one hour, depending on temperature of water, etc. At Kensico and Dunwoodie plants of New York City we regularly use a one-half hour interval for color development and have for several years.

Under "False Color" bottom of page 186 and top of 187 the blue or green color is due to too little acid because of using only 5 drops. A constant sufficient quantity of orthotolidin should always be used to match the standards and avoid reds due to too little orthotolidin and blues due to too little acid.

On page 187 should be added data on the efficiency of B. coli elimination by usage of the residual chlorine control. The great improvement over old practice is not sufficiently emphasized; e.g. New York City at many plants by maintaining only 0.1 p.p.m. residual keeps B. coli absent in 100 cc. in daily tests practically the year round.

Under Aeration, page 190, next to the last paragraph might be added "Secondary aeration between filters and clear water well to remove odors and excess chlorine is practiced at Providence, Rhode Island, West Palm Beach, Florida, Poughkeepsie, New York, Rahway, New Jersey" (Engr. News Rec., Pirnie, volume 99, Sept. 8, 1927, p. 376–80).

In connection with Coagulation pages 205–207, might be added data on use of coagulation and sedimentation to remove turbidity when filtration is not available. New York City's experience last winter was rather interesting. On a smaller scale it has been practiced before. Turbidity started with about 100 p.p.m. and required six months to drop to 5 p.p.m. Treatment with alum required one grain per gallon with 100 turbidity and one-half grain per gallon with

20 turbidity. Soda to counteract acidity was used in molecular proportions at first, one-half grain against one grain of alum. Later it was only dropped to 0.4 grain against 0.5 grain of alum with no bad effect upon the floc and a resulting higher pH. The chemicals were added above Kensico reservoir and there was about three weeks sedimentation before the water passed out of Kensico to the City. The highest turbidity in water delivered to the City was 7 p.p.m. averaging 5 p.p.m. for January and gradually dropping to 2 p.p.m. Efficiency may be said to have ranged from 95 to 90 per cent removal, high to low turbidity. Deposit in Kensico was confined chiefly to the upper one-half mile or so. Distance to outlet is about $2\frac{1}{2}$ to 3 miles. There has been no trouble noted by effect of this last fall's overturning of the reservoir water upon the alum floc deposits.

On page 223, Removal of Color, it is stated that little "true" color is removed by rapid sand filters. I do not understand this statement since this is one of the chief functions of this process. In fact the average removal of color is 40 p.p.m. per 1 grain per gallon of alum (The Relation between Aluminum Sulphate and Color in Mechanical Filtration, Jour. Ind. Eng. Chem. volume 6, August, 1914, page 632).

On page 223, Removal of Microscopic Organisms, the statement should be added that more attention is being paid, and successfully, in lengthening filter runs by use of chlorine and copper sulphate to control organisms; e.g. prechlorination, 1 p.p.m., at Sacramento, California, of the raw water before aeration has removed 75 per cent of algae odors (Western Construction News, volume 12, Oct. 10, 1927, p. 76–77; Public Health Engr. Extracts). (See also 6th Annual Report of Ohio Conference on Water Purification, Oct. 21–22, 1926, p. 10, p. 23, p. 30). Also many other recent papers.

To the Chapters on Filtration might also be added data from the studies on load published by Streeter (Public Health Bulletin No. 172; also Reprint 1170, Public Health Reports, July 15, 1927).

The chapter on Water Softening is excellent except that the calculations on pages 154–155 are somewhat incomplete, e.g. no method is given for calculating total caustic alkalinity. A somewhat fuller explanation of the why and wherefor would seem advisable.

At the end of the chapter page 263 might be added additional data on combination of zeolite and other treatments as planned at Columbus, Ohio. (See Ohio Conference on Water Purification, Report 1926, page 68.)

Under Treatment of Water with Iodide, page 283, table, center of page, opposite 130, "New York City" should replace "Toronto." A second 130 should be added corresponding to "Toronto."

Under Corrosion, pages 412–413, the portion on "Treatment to Prevent Corrosion" might better be removed, enlarged and included under the general section "Treatment of Water" (under discussion). Considerable attention in the future will be given to this subject.

Additional subjects to include in the book might be "The Control and Treatment of Swimming Pools" and possibly also "Boiler Water Treatment."

CHAIRMAN BECK: Dr. Hale, I am sure your work will be of great value to Mr. Fuller and his Committee and I know they appreciate it very much.

This subject will be discussed by Mr. Frank W. Green, Superintendent of Filtration, Passaic Water Company of Little Falls, New Jersey.

MR. FRANK W. GREEN: This whole subject has to be reviewed until we find out just what we are trying to do in the Manual, whether this Manual is to be for the smaller operators who have little technical education or if it is for the members of the societies. Is it to be for the ones who are particularly interested in handling the certain sections or for those who are not familiar with those certain sections, but who cover it broadly so that the other members can refer to these sections and get out of them what they want?

As far as I know, they never really decided whom the Manual was for and, of course, that makes a great deal of difference in how to handle the whole matter. In reading over Chapters 6 to 12, it looks as if the things that are intimately known by the members were slurred over and those which are of momentary interest were given a good deal more space and discussion. For instance, the subject of iodin, which only a certain section of the country is interested in, is given about 18 pages, which is about as much as the whole subject of filtration is given. If we do go into the filtration end of it, it is a question as to whether we want to put in only the usual practice at this time or whether it should be discussed from the point of view of an ideal filter and then show where we are limited and why we do not put out ideal filters. That is the way steam engines used to be treated. They would give an ideal steam engine

and show where all of the heat went and all of the different things, and when they got through they usually found they were using 5 per cent of heat units. I do not think we do quite as badly as that in filters, but we are far from ideal at present and there is a question as to how we can get nearer the ideal—whether we should try to have this as an index of how far we have gone, so that those who are carrying on the good work will have something to which to refer in the way of carrying it a little further, or whether this Manual should be for the smaller men in order to give them just the essential facts and then have the subjects which are at present being discussed and studied carried on in some other way.

The following discussion was prepared by Mr. W. J. Ryan for inclusion in the record, although it was not presented at the meeting:

"P. 262—line 18—insert the following:

"In modern zeolite softeners the time required for this regeneration is about thirty minutes.

"P. 263—first paragraph should be changed as follows:

"The salt required for regeneration of the zeolite is usually one-half pound of salt for a thousand grains of hardening salts removed, expressed as calcium carbonate, but with a very few waters there may be required three-fourths of a pound or in exceptional waters up to one pound of salt per thousand grains of hardness.

"P. 263—paragraphs two and three should be rewritten as follows:

"The zeolite process is particularly applicable to conditions requiring water practically free from calcium and magnesium compounds, such as for boiler feed, for use in laundries and for the textile and dye industries. In recent years the process has come into extensive use for softening boiler feed water. In many waters of comparatively low hardness, of which a considerable portion is non-carbonate hardness, the zeolite process will give a water with a lower content of total solids than would lime soda treatment, in addition to eliminating the calcium and magnesium.

"With waters high in carbonate hardness, lime soda treatment is sometimes followed by zeolite, or the zeolite process alone may be used. Zeolite treatment, although it does not reduce the dissolved solid content of such a water, keeps these dissolved solids in solution even when concentration takes place as in boilers. Therefore the liquid in the boilers remains clear and free from suspended matter, and the heating surfaces of the boiler remain free from sludge or scale. To prevent excessive concentration, the boilers are blown down. The latest improvement in boiler blowdown control is to make the blowdown continuous. A small continuous stream from the boilers is passed through heat exchangers counter current to the feedwater so that the latter thus absorbs the heat of the blowoff stream. This method of blowdown was only successful after zeolite treatment was developed because the clear condition of the liquid in the boilers fed with zeolite treated water keeps such blowdown apparatus free from deposits."

CHAPTER 15

Mr. F. G. Cunningham:[7] The purpose of this discussion is to draw out constructive criticism of this chapter, pointed toward an ultimate revision of the Manual. Since the Manual was written there have been no conspicuous changes in what may be called the art of pumping station engineering and yet I feel that this chapter, like most others in the book, can be made considerably more useful by thorough revision. For one thing it is somewhat unbalanced as regards relative spaces allotted to the different topics. For another, it seems to need a broader summarizing treatment of the principal factors to be considered in choosing pumping station equipment. As now written, each type of equipment is dealt with separately and on its own merits, whereas in every day problems a pretty complete study of the entire station and of future conditions is apt to be needed in order to make a wise selection of a given pump, boiler or important auxiliary.

The task of preparing the first edition of the Manual, with so many authors and with the need for reconciling divergent viewpoints, was great and it was inevitable that the book should lack something in balance and cohesion, so criticism should not be interpreted as reflecting in any way upon the excellent work of the original authors.

Allocation of space. The space in the present chapter is allocated approximately as follows: 50 per cent to boiler room equipment; 40 per cent to central station pumps of all types, including high and low service; 10 per cent to well pumps.

Quite a little of the space under boiler room equipment is used in explaining the common types of boilers and fundamental principles of good boiler room operation, which procedure is not followed where the text turns to pumps.

The amount of space devoted to each topic in the chapter perhaps should be governed mainly by two principal factors as follows:

a. The number of readers likely to be concerned with the topic.

b. The relative amount of money, for first and operating cost involved in equipment of the type discussed, or in other words the importance of using sound judgment in its selection.

Of course it is recognized that of two equally important topics the more complex would require the more space.

In judging as to the character of water plant with which the aver-

[7] Of Fuller and McClintock, Engineers, New York.

age water works official is concerned, it is interesting to note that nearly two-thirds of the 7000 water supplies in this country are taken from ground water and involve pumping from wells. The average demand upon each of the 7000 plants is about one million gallons per day, corresponding to an average population served of perhaps 10,000.

I believe these facts indicate first, that the subject of well pumps which is given only four pages or ten per cent of the space in the present chapter, is too meagerly treated, and second, that equipment of various types suitable for small central stations is subordinated too much in comparison with equipment for large and relatively elaborate steam stations.

The sections dealing with boiler room equipment which occupy about half of the chapter might well be condensed especially by omitting or shortening those parts which merely describe fundamental types of boilers, etc. It may be assumed, as is done in connection with pumps, that the reader already knows one type from another and if he does not there are plenty of more complete works to which he can refer.

My suggestions as to space allocation may be summarized about as follows:

1. Expand and set apart in a separate chapter the material on well pumps. The separate chapter is suggested because there is so little in common between well pumps and central station pumps.
2. Revise and expand the material on pumps driven by electricity and Diesel engines.
3. Shorten the part dealing with boiler room equipment.
4. Insert a section dealing with the broader principles of selecting equipment and determining the best type of plant, as explained below.

General principles of selecting equipment. The speaker does not pretend to have here a complete plan for rewriting Chapter 15, hence his comments under this heading are made only in sketchy form to illustrate an underlying idea. He believes however that there should be an effort made in this chapter to summarize better the main points to be considered in choosing types of stations and equipment.

Suppose for example the problem is to decide the type of pumping equipment in a certain entirely new station. Ordinarily the selection would be made from motor-driven centrifugals using purchased power, cross-compound steam engines, condensing steam turbines,

or Diesel engines. Each type has its merits but one or more types may be eliminated at once by local conditions. It can be said that electrically driven centrifugals and Diesel units are available for the entire range of ordinary head and capacity conditions; Steam stations, however, can seldom be justified on economy unless the average horsepower load is above a certain minimum, say 200, because in small steam plants the first cost and operating cost per million gallons capacity are decidedly higher. The most conspicuous and inherent advantages and disadvantages of each type of pumps are not hard to define. Thus, the outstanding advantages of electrically operated pumps using purchased power are (*a*) minimum first cost for pumps and building (*b*) minimum maintenance and labor cost and (*c*) due to low first cost the owners are left more free to scrap equipment and substitute equipment of different size or arrangement whenever expected or unexpected conditions make such course advisable. The disadvantages are (*a*) deficient reliability where pumping directly to mains, unless unusually ample elevated storage is available (*b*) lack of flexibility for following rapidly changing loads (*c*) monthly bills for power in nearly all cases are decidedly higher than the corresponding fuel cost for a steam or Diesel station would be.

Diesel engines of all sizes can as a rule produce energy with a lower fuel cost than any other source of power, but as against this their first cost is relatively high, which is particularly serious where a large part of the installation is normally idle, and the suitable connection of a Diesel engine to a pump is less satisfactory mechanically than the connection of other prime movers to pumps.

One could go on with similar general statements regarding the other types of pumping equipment but the above comments probably illustrate the point well enough.

In deciding as to type of station and equipment it is usually worth while to develop layouts for the competing types rather fully, taking account of size and cost of buildings and auxiliaries as well as pumps. After estimating relative first costs the next step is to compute annual costs, for fixed charges, operation, maintenance and repair. Annual depreciation and maintenance allowances will vary of course with the character of equipment.

In estimating annual operating charges it is best to visualize as well as possible the actual conditions under which the equipment will operate, taking account of hourly and daily variations in demand, the way in which equipment could be made to respond to variations, power consumption and operating cost of auxiliaries and such factors.

One of the commonest errors is to compare pumps directly on the basis of their full load test duty, without allowance for auxiliary power and in disregard of the fact that the units would seldon operate at rated head and capacity. This procedure is least at fault as applied to high duty reciprocating pumping engines but is apt to be quite wide of the mark for other types. A turbocentrifugal unit for example under usual service conditions will operate at less than full capacity and with considerably less than full load duty, the auxiliaries for it may use a substantial amount of power, and the efficiency of the entire unit naturally suffers appreciable deterioration in service. The accumulated effect of these conditions makes actual overall service duty much less than full load original test duty.

The power consumed by boiler room and other general station auxiliaries, steam pipe losses, fuel used for banked fires, and other losses, all vary in some proportion to the steam used by the main pumping units and should be considered also in comparing competing pumping equipment. These losses are more or less paralleled in a Diesel engine plant where the auxiliary services such as for cooling water create substantial operating charges.

In a steam plant one of the most important and complex problems is to minimize the steam consumption of small non-condensing auxiliaries and in some cases of low service pumps, so that there will be anything less exhaust steam than is ordinarily needed for feed water heating. Careful study is required in each case to find economical means of driving such devices, many of the staple devices being terrific steam-eaters. In some recent stations, notably the Fairmount station at Cleveland, very liberal use is made of auxiliaries driven by pressure water from the main pumps and with excellent effect on economy. Another method being used considerably now, where the main pumping units are steam turbines is to mount a small generator on the shaft of each main unit, the power output from each generator going to a central board whence it is distributed to the apparatus to be driven. Judging from the number of existing steam pumping stations in which the overall plant duty is unnecessarily low, being half or less of the individual duty of the main pumps, I think it is apparent that these considerations are fully as important as selection of the main units.

The discussion above relates primarily to new stations, but applies in considerable measure to new equipment for old stations. In

many of the latter cases, however it may be sound policy to continue the use of old equipment and to restrict for example, increases in steam pressure or temperature or other changes, rather than spend too much in modernizing the station. Obviously the fixed charges on old equipment will go on anyway whether the equipment be discarded or kept in use, and this fact alone alters the basis of comparison.

The comments above may seem overly elementary and general but the principal excuse for offering them is that the factors which should affect choice of equipment are so often wholly or partly disregarded. These comments are not submitted as being complete or suitable for text in the Manual but merely to illustrate the need for some text along these lines. I assume that it is fully as important to set out in the Manual underlying facts and principles as it is to make it useful as a reference book of details. The suitable solution of any problem in selecting pumping station equipment requires thoroughness and investigations which often take one far afield from the original issue, and these often lead to conclusions quite different from preconceived ideas. The meat of all of this might be summed up in one injunction: Make a separate study of each case and do not buy any important equipment without considering all of the collateral effects and the station as a whole.

MR. LEON SMALL:[8] In studying that chapter of the Manual devoted to Pumping Station Practice, the impression gathered is that due weight and consideration has not been given to the advantages and economies of pumping with motor driven centrifugal pumps. It cannot be disputed that this means of lifting water is becoming increasingly important and indeed, we believe, that it is only a question of a few years before motor driven centrifugals will be in the ascendency and occuping their rightful place in the van. Yet, if we were to judge by the manner in which motor driven centrifugal pumps are presented, discussed, and disposed of in the Manual, a reader would be influenced to think that the subject was one of the minor and possible means of lifting water, instead of representing a modern development that is worthy of more than passing recognition. As an instance in support of this, we need but refer to the space devoted to boilers and boiler room practice and compare with that given to motor driven centrifugals. More than 18 pages is given to

[8] Mechanical Engineer, Water Department, Baltimore, Md.

types of boilers, conditions affecting operation, and advantages and disadvantages of different types under operating conditions, costs, ratings, stokers, draft and chimney design, superheaters and economizers, boiler room instruments, etc., and on motor driven centrifugal pumps, less than 4 pages disposes of the entire subject. It is not the intention of this article to criticize the space that has been given to boilers and their appurtenances, and certainly the economical and safe generation of steam is worthy of the space that has been devoted to it, but we submit that the increasing importance of motor driven centrifugal pumps qualifies this branch of the practice of pumping for certainly more space than has been devoted to it in the Manual.

Under the subject of motor driven centrifugal pumps, the statement is made that the low cost of power has made the motor driven pump suitable and economical for the smaller plants and in *many* cases even for large installations. We believe that this could be more accurately expressed if the statement was that the motor driven centrifugal pump is more suitable and economical in *most* cases even for large installations. With current available at a total cost of not more than 1.2 to 1.4 cents per kilowatt hour, the large installation that can show a saving using any kind of power compared with electric drive would be exceptional, when we take into consideration all the elements involved, such as land, building, crane, foundations, etc., and properly include the fixed charges on these in making our comparison. In addition, the electric drive permits the installation of a pumping station in districts where any other type of power would be prohibited, unless we are to run the risk of incurring the ill favor of influential residents, this possibly mounting up to the magnitude of an injunction. With the electric drive, however, a pumping station can be built, if necessary, squarely in the middle of an exclusive residential district and proper provisions made so that not the least indication of the use of the building would be given by sounds transmitted, as these would be absent.

In the Manual, reference is made to the fact that a standby equipment with gasoline and oil power is sometimes provided to secure continuous service, or the latter is insured by two separate and distinct transmission lines. It might be inferred from this that the separate transmission lines would not give the assurance of continuity of operation that could be obtained with a standby with other power, and from the fact that a distinct section is devoted to gasoline engine

auxiliaries, this inference is certainly given weight. Judging from an operating experience of more than twelve years with motor driven centrifugal pumps, during which period careful records have been kept of the number, cause and duration of electrical outages on a large municipal water system, entirely electrified with the exception of one moderate size steam plant, we are led to the belief that for all purposes, continuity of service with electrical drive can be depended upon fully to the extent that dependence can be placed in any type of prime mover pumping plant, provided the feeder lines are led to the pumping station over independent routes and are supplied by a power system that has the interchange and multiplicity of power sources which characterize the modern power system. And if, as would be true in a large municipality, the feeder cables are carried under ground through two separate routes, we would not hesitate to place entire dependence in electrical pumping for 100 per cent of the time.

If space in the Manual could be provided for detail discussion regarding types of boilers, etc. we believe a similar amount of space could be advantageously and consistently given to a more elaborate treatment of the electric drive. No mention whatever is made of unit costs and in fact the whole subject is treated as though motor driven pumps find their place only in the smaller sizes. Types and skeleton characteristics of motors are mentioned, but transformers, controls, automatic operation, and other highly important factors in electric pumping station design are not even referred to by so much as a hint.

In innumerable small pumping stations, the utmost in economy can be gained by the adoption of motor driven centrifugal pumps automatically operated. We believe this subject alone is worthy of at least a separate section, but it, too, fails to be noticed. The writer has designed several of these stations, one of which has been in operation for the past three years and aside from electrical trouble caused by lightning storms, has given uninterruped service. This particular installation pumps into a standpipe and at no time since the installation was started have the consumers felt a diminution in water pressure, the standpipe reserve being ample to carry the system for the brief time necessary to correct the trouble caused by lightning. These automatic stations are designed so as to be frost proof and practically noise proof and combine advantages which can be no-

where approached by any other form of power utilization for water pumping as yet developed.

The above statements are not prompted by any animus, but merely represent the thoughts of the writer on a subject which he believes has been somewhat slighted in the book, which is the result of a great deal of time, thought and energy by water works engineers, and representing as it does, a compendium of knowledge on the entire subject of water works engineering, he believes it is not truly representative unless the advantages and possibilities of electrical drive are presented with the completeness the subject deserves.

Mr. Wm. W. Brush:[9] I should judge from this that Mr. Small is in favor of electric drives.

I did not expect to discuss this question in the Manual, because I am afraid I am like the majority of those present. I have not read the Manual with the care that I should to enable me to discuss it. When Dr. Hale was giving his discussion the thought came to me that many of us need that chapter written with great care, because we know so little about it that we have to take what is given as being gospel truth. It is very desirable that that proportion which would be controversial should, if set forth, and probably it should be set forth, be set forth very clearly, as Dr. Hale indicated, as being controversial. The Manual, as I see it, is for all of us. It must necessarily be, in part, a middle-of-the-road book; that is, it will have to leave out some things that some of us would like to have in and it will have to put in some things that others of us might think could be left out.

The revision of the Manual will require a great deal of work, not perhaps as much work as was necessary to write the original; but if as much or more work could be put into it, it would certainly be worth while from the viewpoint of all of us. Unless we each do our part, we are not going to get the result we are looking for. It really is up to everyone to take that portion of the Manual covering the subject about which he knows something and read it and see what there is in it that he believes should not be or that is expressed in a way which he believes is not such as to give a clear view. Our view may not be the correct one, but those who will be responsible

[9] Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

for the revision of the Manual need to have the views of the majority of us in this Association on that portion of the book about which we know something. The other portions that we do not know anything about or that we know so little about that our opinions are not of value will have to be taken care of by somebody else. But among all of us there are men who know definitely what represents good practice in some particular branch. That is what we should state and state in detail to those who are trying to carry on this work for us in revising the Manual.

Dr. Hale gave us some very definite detailed suggestions which, I am sure, will be of great value to those who have to revise the Manual. The other speakers gave us points which will also be of great value to the revisers of the Manual. But, again, we can all do our part and take that particular portion of the Manual we know something about, read it very carefully and then write to the editor and let him know what we think should go in that is not in there and what should come out that is in there. If we do that, we shall have a cross-section of present-day water works practice which, as the title of the Manual indicates, is the object of the book, and which should change from time to time as our practice changes.

EDITORIAL COMMENT

"FREE WATER," A MUNICIPAL HERITAGE

Those individuals who wrestle eternally with the fiscal policies of municipal water departments recognize the confusion on the part of the layman as to the difference, if any, between consumer and taxpayer and the desire to get something for nothing. The conception of water as a "free good" has passed down through decades as the survival of a truism in the minds of many persons in spite of the argument, example and conflict of hundreds of courageous and public minded water works officials. People now admit sometimes that the collection, treatment and delivery of water cost money. Few are yet ready to agree that the cost should be borne by those who use the water or that *all* those should pay who use the commodity.

Taxes and service rates in any form are complex. Their origin and equity rarely are intelligible to the average citizen. Sentiment frequently plays a peculiarly important part in establishing precedents for charges or omission of charges, while the desire for simplicity frequently overshadows the effort to attain equitable procedures.

Although water supply fiscal records show many dubious forms of payment and policy, the consumers and taxpayers in many municipalities still fail to recognize their import. Why a private cemetery should obtain free of charge all of the water it cares to squander, while a private garage should pay for its water is a problem in ethics and sentiment quite remote from that of logic.

In the Manual of Water Works Practice in 1925, it is stated that 108 cities furnished from 0.1 to 2.5 per cent of their total pumpage as "free water," while 47 supplied as much as 3 to 40 per cent of their total pumpage with no cent of revenue. Fall River,[1] Mass. in 1916 delivered almost 18 per cent free of charge. If water were truly free to all, little exception could be taken to discriminations as still exist, but where water departments are now paying annual rentals for office space in city halls, are charged with services rendered to them by other bureaus and are operating on independent budgets,

[1] Jour. N. E. W. W. Assoc., Vol. 30, p. 391, 1916.

the logic and equity of "free water" practice become even more tenuous than hitherto.

Would the consumer on a private gas or electric utility remain supine, if he discovered that the company was supplying free of charge unlimited amounts of its commodity to several hundred charitable, semi-charitable, and private institutions in accordance with a sentimental decree of its former president fifty years ago? It is doubtful. Yet this is almost standard practice in many municipal water bureaus.

The gravity of the situation is strikingly presented at this time in a mimeographed copy reaching the editor's desk of a "Communication to the Utilities Committee of the City Council of Cleveland, Ohio," under date of January 21, 1928. The communication was prepared by Howell Wright, Director of Public Utilities. Some notations from this memorandum are reproduced here for their forcefulness and usefulness in presenting the problem of free water.

TABLE 1

Water consumption in schools, Cleveland, Ohio

	1924	1925	1926
School enrollment	135,911	138,678	139,168
Consumption of water (gal.)	1,180,212,500	1,183,024,000	1,319,236,000
Gallons used per pupil per year	8,662	8,531	9,479
Gallons allowed per pupil per year by ordinance	3,000	3,000	3,000
Excess over reasonable and normal use per pupil per year	5,662	5,531	6,479
Percentage of excess	188.74	184.37	215.97

In 1926 the filtered water pumpage in Cleveland was 8,245 million cubic feet. Of this amount, 2,184 million cubic feet, or 26.48 per cent, produced no revenue. It represented water furnished free for fire protection, street cleaning, sewer flushing, parks and playgrounds, public schools, parochial schools, public buildings, city cemeteries, city markets, public libraries, charitable institutions and miscellaneous losses in the water system itself. Losses due to pump slippage are estimated at 3 per cent and to slippage of meters at 3 per cent.

The City Council, in providing for free water service to the above, stipulated certain maximum allowable daily per capita uses in the institutions metered, as, for example,

Public Schools, 15 gallons per capita, for the average attendance per day during such days as schools are in session, payable August 1, for the preceding twelve months, but payable August 1, 1909, for the previous six months.

TABLE 2

Analysis of revenue loss through free water, Cleveland, Ohio

The amounts of free water consumed by city departments, schools, hospitals, public buildings, cemeteries and charitable organizations and loss of revenue therefrom during 1924, 1925 and 1926. This is metered consumption.

	1924		1925		1926	
	Consumption	Revenue loss @ 8¢	Consumption	Revenue loss @ 8¢	Consumption	Revenue loss @ 8¢
	gallons		*gallons*		*gallons*	
158 Public Schools	1,180,212,500	$94,417.00	1,183,024,000	$94,641.90	1,319,236,000	$105,538.90
99 Parochial and Private Schools	133,310,000	10,664.80	121,886,000	9,750.90	107,684,000	8,614.70
17 Hospitals including City Hospital and Warrensville Farms	440,730,000	35,258.40	448,882,000	35,910.60	498,860,000	39,908.80
61 Charitable Institutions	205,050,000	16,404.00	197,336,000	15,786.90	206,260,000	16,500.80
77 Public Buildings, including City Hall, 35 Police and 21 Fire Stations, 4 markets and 16 libraries	448,470,000	35,877.60	491,849,000	39,347.90	454,214,000	36,337.10
13 Cemeteries (9 City and 4 Private)	57,585,000	4,606.80	57,929,000	4,634.30	98,586,000	7,886.90
Totals	2,465,357,500	$197,228.60	2,500,906,000	$200,072.50	2,684,840,000	$214,787.20

All such institutions as enumerated in the foregoing shall pay for all water used or that passes through the meters supplying said institutions, etc., at the city meter rate, for all consumption above such maximum.

No payments for excess use, however, have ever been made. Table 1 indicates how this practice has resulted in considerable excess use.

Table 2 is particularly instructive in indicating how the use of "free water" is costing the water department of Cleveland in excess of $200,000 annually in loss of revenue. Mr. Wright further points out the blindness of granting "free water" in exchange for supposed advantages to the city of one kind or another, which advantages later turn out to be somewhat disconcerting. He states, for example,

At the 1927 Budget hearings we were advised that appropriations would be made for water used by City Markets, City Cemeteries and the City Golf Courses. The loss in revenue from water furnished these divisions is, in dollars,

	1924	1925	1926	1927
City markets	3,039.60	2,704.80	4,266.00	3,473.40
City cemeteries	1,390.80	1,721.40	1,630.80	2,041.80
City golf courses	5.40	42.00	51.00	46.20
Totals	4,435.80	4,468.20	5,947.80	5,561.40

In the case of private cemeteries, four get water free and about a dozen pay for water used. We believe there is no authority for furnishing free water to private cemeteries. In the case of Lakeview Cemetery, the City Council, in October, 1895, passed a resolution exchanging free water in perpetuity for a certain strip of land to be used for street purposes.

Since this contract the Department has furnished the cemetery with 74,768,000 cubic feet of water at a cost of $38,410.90. The use of water by the cemetery is increasing. From January 1, 1924 to April 1, 1927, we have furnished 20,522,000 cubic feet at a cost of $13,001.90.

The principle that water works funds should be used for water works purposes is one of long standing. Why it is so persistently ignored it is difficult to state. T. S. Adams,[2] the eminent taxation authority, sheds some light on the difficulty in his discussion of taxation in general. He remarks that:

[2] "The Relation Between Industry and Taxation," Mechanical Engineering, Vol. 50, No. 2, Feb. 1928, p. 113.

tax making is a hard game, in which the class that does not work for its own interest loses that interest. Taxes do not merely happen; they are forged in the heat of a class struggle which, although ordinarily conducted within the bounds of decency and law, is none the less a struggle. Taxes emerge—to change the simile—as a resultant of these jarring forces; and no group of men is disinterested or scientific or wise enough to make tax laws for other groups without the active participation of the latter in the making thereof.

The water works official perhaps must take his cue in the effort to eliminate the inequality of the "free water" principle from other fields. That cue is one of persistence in education of consumer and taxpayer in the merits and demerits of fiscal policies. He may be heartened in this task by Professor Adams' further comment that

The historical fact is that modern states prefer equity and complexity to simplicity and inequality. The cry for equality and justice is louder and more unanswerable than the demand for certainty and convenience. . . . . In the light of financial history, simplicity is a lesser god.

ABEL WOLMAN.[3]

[3] Editor in Chief, Journal of the American Water Works Association; Chief Engineer, Maryland Department of Health.

SOCIETY AFFAIRS

KENTUCKY-TENNESSEE SECTION

The third annual meeting of the Kentucky-Tennessee Section convened at the Kentucky Hotel, Louisville, Kentucky, on January 19, 1928, with W. S. Patton presiding.

The Honorable William H. Harrison, Mayor of Louisville, extended greetings on behalf of the city. Col. F. W. Albert responded.

"Water Supply and the Public Health" was the subject of an address by Dr. P. E. Blackerby, Assistant Secretary of the State Board of Health of Kentucky.

After appointment of committees, the meeting adjourned until 2:00 p.m.

"Service and Public Relations" was given by W. C. Stair, Middlesboro, Kentucky and was discussed by J. E. Davis, W. S. Cramer, F. W. Albert, S. L. Allen, C. A. Orr, and James Sheahan.

"Water Works Supervision and Coöperation with the Water Works Department" by A. E. Clark, Nashville, Tennessee, was discussed by F. C. Dugan, J. H. Swope, W. S. Cramer, and W. S. Patton.

"The Use of Uranine Dye in Tracing Underground Waters" by A. W. Crouch, McMinnville, Tennessee was discussed by F. C. Dugan, James Sheahan, and F. W. Albert.

Major J. H. Howland of the National Board of Fire Underwriters spoke on "The Standardization of Fire Hose Threads." A general discussion took place and the Resolutions Committee was instructed to prepare a statement for action by the section.

The Nominating Committee reported that the new Executive Committee would consist of Col. F. W. Albert, Knoxville, Tennessee, Chairman; W. H. Lovejoy, Louisville, Kentucky, Vice Chairman; C. A. Orr, Mayfield, Kentucky, Director; and A. E. Clark, Nashville, Tennessee, Director. The Executive Committee reelected F. C. Dugan, Louisville, Kentucky, Secretary-Treasurer.

A get-together dinner was held at 6:30 p.m., after which motion pictures were shown by The American Rolling Mill Company.

The section reconvened at 9:00 a.m., January 20.

Major J. H. Howland read a paper entitled "Requirements for Fire Protection and Methods to Determine Quantity Available." It was discussed by J. L. Thompson, F. W. Albert, A. Clements and W. S. Cramer.

"The Design of a Distribution System" by A. P. Learned, Kansas City, Missouri, was taken up and discussed by F. W. Walbert.

"The Development of the Distribution System of the Louisville Water Company" by L. S. Vance, Louisville, Kentucky, was read and discussed.

The afternoon session was devoted entirely to "Management of Water Works." Mr. W. S. Cramer, Lexington, Kentucky, discussed "The Management of a Privately Owned Water Works." Col. F. W. Albert presented a paper on "The Management of a Municipally Owned Water Works," and W. S. Patton, Ashland, Kentucky, a paper on "Some Problems in Management." The papers brought forth considerable discussion.

The Vogt Brothers Manufacturing Company entertained the members with a supper at their plant.

The morning of January 21 was devoted to papers on water treatment.

"The Water Supply Situation in Kentucky" was given by E. E. Jacobson, Louisville, Kentucky.

"The Progress of Water Supply Purification in Tennessee" was given by H. R. Fullerton, Nashville, Tennessee.

"The Design and Construction of Small Filtration Plants" was given by H. K. Bell, Lexington, Kentucky and discussed by C. N. Harrub.

"The Trials of a Small Filtration Plant Operator" were discussed by W. H. Johnson, Harrodsburg, Kentucky and D. J. Niemeier, Shelbyville, Kentucky.

"Algae Control by Artificial Turbidity" by W. H. Lovejoy, Louisville, showed what was being done by the Louisville Water Company on this subject.

The Committee on Resolutions reported and their report was accepted.

An inspection trip to see the methods used in cleaning underground pipes and the filtration plant of the Louisville Water Company took up the afternoon session.

Announcement was made that the 1929 meeting would be held in January at Knoxville, Tennessee.

The following resolutions were passed.

WHEREAS, the Kentucky-Tennessee Section of the American Water Works Association has since its last meeting suffered a grievous loss by the death of our past Chairman, Carl E. Davis of Memphis, Tennessee, and

WHEREAS, his faithful work and active support was largely responsible of the success of this organization, therefore

Be It Resolved, that the Kentucky-Tennessee Section in convention assembled, express its deepest sympathy to the family of Mr. Davis, and

Be It Further Resolved, that a copy of this resolution be spread upon the minutes.

WHEREAS, the Kentucky-Tennessee Section of the American Water Works Association has since its last meeting suffered a grevious loss by death of Mr. Newton Mitchell of Paris, Kentucky, who was most interested in the work of the Association and who was a regular attendant until ill health prevented, therefore

Be It Resolved, that this Association mourns the loss of our colleague and extends to the family of Mr. Mitchell its deepest sympathy, and

Be It Further Resolved, that a copy of this resolution be spread upon the minutes.

WHEREAS the Standardization of Fire Hose Threads is a nation wide movement to enable cities and towns to render effective aid to their neighboring municipalities in the event of large spreading fires, and

WHEREAS there is a wide variety of threads existing in Kentucky municipalities, the great majority of which are not interchangeable one with another, and

WHEREAS the Kentucky Actuarial Bureau and the National Board of Fire Underwriters are prepared to coöperate to the fullest extent in advancing the necessary field work, therefore

Be It Resolved that the Kentucky-Tennessee Section of the American Water Works Association unqualifiedly endorses and approves of the state wide standardization of fire hose threads in the State of Kentucky.

WHEREAS, the discharge of phenol wastes into the Ohio River and its tributaries has endangered the water supplies of the municipalities using water from these sources, and

WHEREAS, the formation of the Interstate Stream Conservation Agreement of the Ohio River Basin, comprising the states of New York, Pennsylvania, West Virginia, Ohio, Illinois, Indiana, Tennessee, Maryland, Kentucky, Virginia, and North Carolina and the formation of the Board of Public Health Engineers of the Ohio River Basin has already resulted in elimination of the phenol discharge from fourteen of the eighteen plants formerly contaminating the waters of the Ohio River Basin with this waste and as the remaining four plants are now under orders from their respective State Health Departments to install means for eliminating phenol discharge from their plants on or before June 1, 1928,

Be It Resolved by the Kentucky-Tennessee Section of the American Water Works Association in convention assembled at Louisville, Kentucky, January 19–21, 1928, that passage of anti-phenol legislation by the Congress of the United States is not necessary or desirable at the present time and,

Be It Further Resolved that this section approves and offers its help to the Board of Public Health Engineers of the Ohio River Basin in its efforts to accomplish the elimination of stream pollution of the Ohio River and its tributaries, as far as this pollution affects public water supplies.

F. C. Dugan,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, **12:** 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of issue, and 16 to the page of the Journal.

Double Coagulation. Its Effect as Shown by Cincinnati Tests. C. BAHLMAN and C. B. EVANS. Water Works Eng., 1064, July 20, 1927. Double coagulation investigated at Cincinnati to determine whether satisfactory water could be produced without chlorination; whether double process would act as an additional safeguard so that chlorination would be truly a factor of safety; whether quality of output could be improved; effect on filter runs, and relative costs of single and double coagulation. Alum used as coagulant gave good results. Results indicated that double coagulation introduces a highly desirable safeguard; a standard chlorinated plant output under extreme raw water pollution may be guaranteed; which is not possible under single coagulation unless greater quantities of chlorine are applied. Double coagulation without chlorine affords adequate protection to consumer, thereby saving him much discomfort from phenol and chloro-phenol tastes. Filter runs increased 30 to 65 per cent, saving from 25 to 40 per cent wash water, except during winter. With ice in reservoir no great saving of wash water possible. Additional cost of double coagulation 36 cents per million gallons. Additional expense not prohibitive in view of advantages.—*Carl Speer, Jr.*

Great Advances in Water Softening. CHARLES P. HOOVER. Water Works Eng., July 6, 1927, p. 991. (1) Great quantities of chemicals economically handled by unloading them from cars by means of pneumatic conveying devices: cheaply elevated into bins from which they are fed into the water by gravity. Installation at new Marion, Ohio, water plant consists of vacuum pump, conveying line with intake nozzle, receiving station, and air filters. Objections raised to this system for unloading lime on the grounds that carbonation of lime takes place when brought in contact with large volume of air. Analysis showed this not so. (2) Two types of mixing devices used: (a) Baffled tanks, (b) mechanical agitators. Over and under type baffled tanks have been successfully used at Columbus plant for the past 20 years. Mechanical agitators cheaper to build and provide greater accessibility and flexibility. (3) Large quantities of sludge formed by the softening reactions now removed continuously by the installation of Dorr clarifiers in the settling basins. (4) Limitations in the reduction of hardness have been largely overcome by (a) the hot process: (b) excess lime treatment: (c) split treatment:

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

(d) excess lime followed by carbonation; (e) use of compounds of alumina, and (f) substitution of zeolite for soda-ash to remove non-carbonate hardness. (5) Where salt may be obtained at a fair cost it is cheaper to remove non-carbonate hardness by means of zeolite than by means of soda-ash. Lime softened water not stable, super-saturated with normal carbonates of calcium and magnesium; distribution system becomes encrusted with carbonate deposits; sand grains grow in size, cement themselves together and finally lose their effectiveness as a filter medium. (6) Lime softened water now being cheaply and satisfactorily stabilized by recarbonating it with carbon dioxide gas, scrubbed and dried before being diffused into water through grid system located ahead of filters. Recarbonation should not increase corrosive properties of the water. Addition of aluminum salts to lime softened water not a substitution for recarbonation.—*Carl Speer, Jr.*

The Poisonous Effects of Copper. J. B. Mallory, M.D. Jour. New Eng. Wat. Works Association, **41**: 1, 27, March, 1927. Copper taken into the body is easily absorbed. Body can handle small amounts, but excess produces cirrhosis. Exposure to copper should be reduced to minimum. Raises question of use of copper for pipes and tanks for drinking water.—*Carl Speer, Jr.*

Micro Determination of Carbonate Carbon. Geo. Kemmerer and L. T. Hallett. Ind. Eng. Chem., **19**: 1352–54, 1927. An accurate method for the determination of small amounts of carbon is given using 5 to 15 milligram samples. The special heating glass apparatus is described and a scheme of analysis presented. A table of results obtained by the method gave very accurate check figures. The apparatus and method of analysis should be of practical value in experimental work.—*Edward S. Hopkins.*

Sixth Annual Report of Ohio Conference on Water Purification, Toledo, Ohio, October 21–2, 1926. 92 pp. **Description and Operating Results of the New Greenville, O., Water Softening Plant.** Frank S Taylor. 18–20. The plant, which treats well water pumped by air lift, consists of two steel mixing tanks providing 27 minutes' retention, 4 dry feed chemical machines Dorr clarifier providing 40 minutes' retention, sedimentation basin providing 5 hours' retention, carbonation equipment comprising coke furnace, compressor, and steel scrubber and dryer tanks, four $\frac{3}{4}$ m.g.d. filters containing 18-inch layer of gravel and 30-inch layer of sand with effective size of 0.45 mm. and uniformity coefficient of 1.28, and chlorination equipment. Chemical treatment consists of 16 g.p.g. lime, 3 g.p.g. soda ash and 0.8 g.p.g. alum. Excess of 1 p.p.m. carbon dioxide is maintained in water applied to filters. Cost of pumping and softening is $120 per m.g., and chemical cost alone is $33.50. Difficulties which have had to be overcome are outlined. Pitting of valves of compressor which has occurred is believed to have been due to sulfur in coke, which amounted to 1.6 per cent. If water is incompletely carbonated loss of head increases rapidly and filters become air bound. Caustic water has prevented algae growths in settling basin, but copious growths have occurred on walls of recarbonation chamber. Total alkalinity is reduced from 365 to 82. Optimum temperature for coagulation has been found to be 22°C. Plant has capacity of 3 m.g.d., and cost was $170,000. **Combination of Excess Lime,**

Double Coagulation, and Adjustment of pH Value at Ironton. E. T. EDWARDS. 21–3. Prechlorination as means of reducing the bacterial load on the Ironton plant, which consists of primary settling basin, mixing chamber, secondary settling basin and 4 one-m.g.d. filters, had to be abandoned owing to taste produced by phenol which is present at all times in the Ohio River water. Double coagulation has been practised for several years. Experiments with excess lime treatment have shown that satisfactory purification can be effected without the use of chlorine. Sufficient lime is added to raw water to maintain causticity of 20–25 p.p.m., and carbon dioxide, produced by burning coke, and sufficient alum are applied in the mixing basin to reduce causticity of applied water to 5 p.p.m. and turbidity to 15 p.p.m. B. coli index of water from primary settling basin is reduced from 20,000–40,000 per 100 cc. to 100 per 100 cc. Increases in turbidity of raw water are accompanied by reductions in bacterial removal in primary basin. Treatment has remedied difficulties due to algae growths on walls of primary basin and filter runs have increased to twice normal length during summer season with attendant reduction of wash water. **Raw Water Chlorination Experiments at Sandusky.** O. F. SCHOEPFLE. 23–6. The plant, which treats Sandusky Bay water, consists of 2 relatively large coagulation basins and ten 1-m.g.d. filters containing 14 inches graded gravel and 36 inches of sand, with provision for air wash. In an effort to reduce the bacterial load, raw water chlorination experiments have been carried out. Average of 0.48 p.p.m. of chlorine was added maintaining residual of 0.02 p.p.m. after 10 minutes' contact, free chlorine being absent in water applied to filters. Treatment reduced load sufficiently to enable production of filter effluent complying with Treasury Dept. Standard. Improved coagulation effected by the addition of chlorine permitted reduction in amount of alum used, reducing chemical cost of purification about 20 percent. The pH values of the raw water before and after chlorination were 7.95 and 7.94 respectively. It is believed that addition compounds rather than substitution compounds are formed when chlorine is added to water. **Description and Operating Results of the Girard Water Softening Plant.** BROOKS D. CHURCH. 26–9. The new Girard 1-m.g.d. purification plant, treating water derived from drilled wells, consists of 2 dry feed machines, 4 mixing chambers providing retention period of 30 minutes, 2 settling basins providing 3½ hours' retention at velocity of 0.38 foot per minute, carbonization chamber and two 0.5-m.g.d. rapid sand filters containing 27 inches of gravel and 27 inches of sand with effective size of 0.41 mm. and uniformity coefficient of 1.6 Carbon dioxide is produced by burning powdered coal. Disinfection is not necessary. Treatment requires 10 g.p.g. lime and 160 pounds carbon dioxide per m.g. Maximum excess of 2 p.p.m. of carbon dioxide is maintained in applied water. Cost of operation, inclusive of pumping, averages $54 per m.g. Hardness is reduced from 192 to 90 p.p.m. **Control of Algae Growths in Impounding Reservoirs at Bucyrus.** A. B. CAMERON. 30–2. Data given on algae control in two shallow impounding reservoirs from which Bucyrus obtains its water supply. During excessive dry spells supply is supplemented by pumping water into first reservoir from Sandusky River. Due to algae growths filter runs were often as short as 4–5 hours during summer and water became highly

impregnated with tastes and odors. During May to October 1925 the reservoirs were periodically treated with 0.25–0.40 p.p.m. copper sulfate at cost of approximately $1 per m.g. Filters runs during this period averaged 23 hours and at no time was there noticeable taste or odor. In 1926 similar treatment was just as effective. Need of treatment is indicated by length of filter runs and by microscopical examinations. **The Inter-Relation of the Problem of Water Purification and Sewage Treatment in Ohio.** Howell Wright. 32–7. Discussion of relation of sewage disposal to water supply with special reference to conditions in Cleveland where sewage is discharged into same body of water, Lake Erie, from which water supply is obtained. Water works funds are being used to operate the Cleveland sewage treatment plants and a bill to establish legality of this was introduced in the General Assembly but was not adopted. History of location of Cleveland's intakes is the history of encroachment of its own sewage pollution on its own water supply. Bacterial data given show that disinfection must be depended upon to produce water of satisfactory quality. Since limitations of water purification are approximately known, obvious conclusion is that more effective methods of sewage purification must be resorted to. Conditions in Toledo are similar. **Experiments with Double Coagulation at Cincinnati.** Clarence Bahlman and E. B. Evans. 37–50. Results of experiments on double coagulation at Cincinnati given in some detail. Normal treatment process consists of 48–72 hours' preliminary settlement, coagulation with lime and iron sulfate in basin providing 8 hours' retention, filtration and chlorination. During experimental period a minimum amount of alum was added to raw water, no other change being made in operation except that considerable reduction in lime and iron sulfate was made possible. Summary of results compared with single coagulation is as follows: (1) Turbidity carried to filters was reduced 50 per cent. (2) Bacterial counts of filter influent and effluent were similar with both systems. (3) Number of B. coli in filter influent was 80 per cent less. (4) B. coli index of effluent was materially less. (5) Chlorinated water was of improved quality. (6) Filter runs were increased 60 per cent, reducing wash water 44 per cent. B. coli index of filter effluent was almost always less than 2 per 100 cc., and less than 1 most of time, disinfection thus becoming true factor of safety that could be discontinued at will. By use of preliminary coagulant periods of high turbidity accompanied by maximum pollution can be entirely prevented from having any effect on water coming to plant for secondary treatment. Total amount of chemical used is ordinarily less in double than in single coagulation, but as alum is more expensive than iron sulfate, an increase in cost of chemicals will result from double coagulation when alum is employed as primary coagulant. **Detention Periods Required for Coagulation of Lake Erie Water at Cleveland.** W. C. Lawrence. 51–5. Data obtained in study of retention periods required for coagulation at Cleveland plants are presented. Definite conclusions can not yet be formed as to most satisfactory detention period. While work was carried out solely for purpose of determining proper detention periods required to obtain good filter influent, it has resulted in saving in chemicals used to extent of $5500 in 9 months. **Preliminary Studies for a New Water Supply for Niles and Youngs-**

town. W. H. Dittoe. 56–7. The Mahoning Valley Sanitary District has been created for purpose of jointly developing solution to water supply problem of Niles and Youngstown, Ohio. Both supplies have become so polluted that it is better to abandon them than to attempt to render them suitable for use. Caustic lime treatment effectively sterilizes both supplies, but they are unsatisfactory due to tastes and odors, high temperature during summer months, and excessive hardness. Procedure by which sanitary districts may be created in Ohio is outlined. **Discussion of Raw Water Chlorination Experiments at Sandusky.** L. H. Enslow. 57–9. Discussion of use of chlorine in treatment of water and sewage. The chlorine first combines with the organic matter with the formation of chloro-substitution compounds and true oxidation does not occur until chlorine demand has been satisfied and free chlorine is present in considerable excess. Improvement in coagulation by chlorination is believed to be due to a change in composition of colloids present (artificial "aging"). A very short period of contact with chlorine prior to coagulant application is not nearly so effective as long period. Superchlorination for preventing tastes due to phenol at Toronto, and use of chlorine for controlling algae growths in Texas are discussed. Aftergrowths following chlorination are considered to be of little significance. **Progress on Coöperation with Ohio Manufacturers in the Proper Disposal of Industrial Wastes.** F. H. Waring. 60–3. Review of progress in control of industrial waste pollution in Ohio. The plan adopted involves closest coöperation with manufacturers, who are organized in groups according to character of wastes. "Save ali" device in use at one paper plant is over 99 per cent efficient and has paid for itself within 10 months. Following conclusions have been formed from results obtained at experimental plant operated by canning industry: (1) Fine screening will easily remove visible suspended matter. (2) Tank treatment is unnecessary. (3) Coarse trickling filters of stone or built up of laths will produce effluent entirely satisfactory for disposal into dry runs. (4) No sludge is produced except screenings. **Improvements in Lime-Soda Water Softening Methods at Columbus, Ohio.** Chas. P. Hoover. 63–71. Theoretical limit for softening by lime-soda process is 2 g.p.g., and this limit cannot be reached in practice unless heat or excess chemicals are employed. This is believed to be due to formation of complex basic carbonates. Chart is given showing theoretical and actual reduction in alkalinity and incrustants by addition of soda ash in increasing quantities to a magnesium water. Efficiency may be increased by split treatment, by proper agitation, and by use of a coagulant. At Columbus it has been found that hardness can be reduced from 318 to less than 60 p.p.m. without use of excess chemicals by adding 5 g.p.g. of alum. Experiments are being conducted on zeolite softening. While it is cheaper to remove carbonate hardness with lime than by base exchange, cost of removing non-carbonate hardness by latter method is only one-half that of soda ash treatment. It is planned to replace sand in one of filters with zeolite sand for experimental purposes. It is believed that hardness can be reduced to 160 p.p.m. with lime, and that to produce water of 80 p.p.m. it will be necessary to further treat only one-half of total in zeolite filters. **Ohio Practice in the Examination of Filter Sand.** W. H. Knox. 71–6. Details given of methods employed by Ohio State Department of Health

in examination of sand for water and sewage filters, including data on sieves used, method of rating sieves, preparation of sample, and procedure for mechanical analysis. Very little change was observed in rating of sieves used from 1914 to 1925. Specifications adopted for sand for rapid sand filters are as follows: effective size 0.35–0.45 mm., uniformity coefficient, 1.7, depth of bed 24–30 inches. Specifications for supporting layer of gravel also included. **The Supervision of Small Water Treatment Plants.** CLARENCE BAHLMAN. 77–81. Experiences met with in supervision of operation of small purification plants, a practice which has been fostered by State Department of Health, are outlined. Importance of teaching operator how to make routine chemical tests and utilize them in plant operation is stressed. Better results may be expected from poor installation operated conscientiously than from modern equipment carelessly handled. **Alco-Floc as a Coagulant and Water Softening Reagent. I. Akron.** J. S. GETTRUST. 81–2. **II. Portsmouth.** F. E. SHEEHAN. 82. Two experimental periods at Akron and one brief period at Portsmouth indicate that alum and lime is more economical than Alco-floc and alum. **New Mechanical Mixing Chamber Added to Portsmouth Filtration Plant.** F. E. SHEEHAN. 82–3. A mixing basin has recently been installed at Portsmouth to facilitate mixing of chemicals and prevent after-precipitation. Basin is of concrete, divided into 4 compartments by baffle walls, and provides retention period of 15 minutes. Total paddle area is 28 per cent of vertical area of tank. Brief experience to date indicates that increased efficiency will be obtained with lower amounts of chemicals. **Progress Report on Raw Water Carbon Dioxide Treatment at Lima.** E. E. SMITH, 2nd. 83–4. Brief additional data given on carbonation at Lima, O. An improved type of coke burner has been installed. Experiments indicated that use of artificial gas for generation of carbon dioxide would increase cost 10-fold. Average amounts of chemicals used during period September, 1925—August, 1926, were: alum 2.27 g.p.g., coke 5.9 p.p.m., chlorine 0.25 p.p.m., average chemical cost per m.g. being $4.56. **Progress Report on Gas-Forming Organism in the Akron Water Supply.** C. O. HOSTETTLER and J. S. GETTRUST. 85–6. Additional data given on gas-forming organism present in Akron supply which ferments lactose broth only after 24 hours' incubation, and on effectiveness of lactose broth containing 0.5 per cent lactose peptone bile for its inhibition. Results show that modified broth does not inhibit B. coli but does inhibit organisms giving rise to fermentation after 24 hours' incubation. Use of modified broth hastens obtaining of results and reduces volume of work. **Open Reservoirs for Filtered Water on the Distributing System.** CLARENCE BAHLMAN. 86–8. Explosive appearance of vigorous positive B. coli tests in tap samples in Cincinnati was traced to contamination of open filtered water reservoir by manure carried by wind from nearby shrubbery beds. The organisms were very resistant to chlorine, and dosages which had to be resorted to gave rise to many complaints of taste. It was more than 2 months after first appearance of contamination until a coli-free water was again obtained. **Comments on the Calculation of the B. Coli Index.** 88–90. Instructions for calculation of B. coli index given to ensure uniformity in expression of results from all plants throughout State of Ohio.—*R. E. Thompson.*

Report on the Working of the Corporation of Madras Water Analysis Laboratory for 1926. 62pp. S. V. Ganapati. Extensive tabulated analytical data given. Consumption during year was 15–19 m.g. per day, of which 12.73 m.g. was treated by slow sand filtration, the deficiency being made up with raw water from Red Hills Lake, the source of supply, which was chlorinated during period July to December. There are 17 filters, 14 of 1-m.g.d. capacity and 3 of 1.33-m.g.d. capacity. Average length of filter run was 18 days, efficient length of run as regards rate of filtration being 10 days. Production of hydrogen sulfide in all beds continued to be disconcerting feature, persisting even when chlorinated water was applied to filters. The water as supplied differed very little from raw water, quality being considerably below all accepted standards. Hankinization of city supply for short period when bleach supply failed gave rise to many complaints of objectionable colored growths due to manganese bacteria. Vibrios appeared in water in July and chlorination was immediately adopted. Chlorination of filtered water was rendered ineffective by the hydrogen sulfide present and point of application was shifted to the raw water. Notwithstanding this treatment the vibrios persisted in the water supplied to the city. It was found that the vibrios were not true V. cholerae. Experiments on double filtration employing bed of coke for primary filtering medium followed by sand filtration at double the normal rate were unsuccessful. **Report on the Investigation Made in Connection with the Presence of Vibrio-Like Organisms in the City Water Supply.** C. S. Govinda Pillai. 60–2. Inspection of territory adjoining Red Hills Lake disclosed accumulations of nightsoil in vicinity of near-by villages which would be washed by rains into the lake. Provision of proper latrine accommodation in the villages, increased vigilance to prevent contamination through water conduit manholes by villagers seeking water, and increased chlorine dosages are recommended.—*R. E. Thompson.*

Flood Control with Special Reference to the Mississippi River. A Symposium. Proc. Am. Soc. Civ. Eng., **53:** 10, 2452–2615, December 1927. **Introduction.** Edgar Jadwin. Controlling the floods of the Mississippi River is a National problem. **Résumé of the Mississippi River Flood Problem.** C. McD. Townsend. Several Acts of Congress between 1879 and 1917 have stipulated the conditions under which the Federal Government has been aiding in flood control on the Mississippi River. The cost of the existing methods of levee construction increases as the square of the height. If possibilities instead of probabilities are to control future levee construction the cost will be so enormous that the economic solution will be found in other methods of flood protection. **Rainfall Characteristics of the Mississippi Drainage Basin.** H. C. Frankenfield. The precipitation over the entire drainage area from January to April, 1927, inclusive was 10.79 inches. This is 2.25 inches above normal. The data indicate that a precipitation of 10 inches in 3 to 4 months from January to April will cause a great flood from Cairo southward. **Run-off Characteristics of the Mississippi River Drainage Basin.** N. C. Grover. The run-off greatly exceeds the channel capacity in the lower part of the Mississippi River. Any plan of flood control should provide additional channels to the Gulf or storage capacity to detain the excess water. **The Work of**

the Mississippi River Commission. C. W. KUTZ. The author gives a résumé of the work of the Mississippi River Commission, and concludes that while protection against a maximum flood of 2,250,000 second-feet at Cairo can be provided with levees, such levees carry with them a menace to the people living behind them that should be avoided if practicable. A system of main river levees supplemented by a series of controlled diversion channels is believed to be the cheapest and most dependable method of controlling the flood flow. **Forest Cover as a Factor in Flood Control.** E. F. MCCARTHY. Forests have a definite part in flood control. The first place to seek control of a flood is at its source where every small impediment is effective in delaying the union of droplets into rivulets and these, in turn, into streams. The litter-covered forest floor is generally the most porous. **Reservoirs for Mississippi Valley Flood Protection.** WILLIAM KELLY. The estimated cost of reservoirs to control the flood flow is probably higher than that of any alternative method that might be adopted. **The Basis of the Case Against Reservoirs for Mississippi Flood Control.** A. E. MORGAN. That levee control is less expensive than reservoirs has never been adequately determined. A study of reservoir control is advocated **Levees as a Means of Flood Control for the Mississippi River.** J. F. COLEMAN. The author is of the opinion that levees, with auxiliary works for the protection of banks from caving, will afford the only certain method of controlling the floods of the Mississippi River. **Improvement of Navigaticn in Relation to Flood Control.** S. C. GODFREY. Navigation and flood control have much in common and few, if any, conflicting interests. Bank stabilization is needed for flood control and will greatly benefit navigation. **The Flood Problem of New Orleans, Louisiana.** MARCEL GARSAUD. The ground surface in New Orleans varies from about 2 feet below to 8 feet above Gulf level. The river level fluctuates from slightly below to about 21 feet above Gulf level. Spillways are advocated. **The Relief Outlets and By-passes of the Sacramento Valley Flood-control Project.** C. E GRUNSKY. Through a large portion of the Sacramento valley the river banks are higher than the adjacent valley land. The flood-control project, described in detail, includes relief outlets and by-passes by means of which the outgoing water is carried down the valley to a re-entry to the river. The estimated cost since 1910 is $51,246,304. **Reclamation as Affecting Flood Control.** ELWOOD MEAD. The effect of reclamation on the Mississippi River itself appears to be negligible, but it has some influence on the tributaries lying in the arid regions. **Power as Affecting Flood Control.** F. W. SCHEIDENHELM. Power developments involving reservoirs usually have a beneficial effect on flood control.—*John R. Baylis.*

Emergency Dam on Inner Navigation Canal at New Orleans, Louisiana. HENRY GOLDMARK. Proc. Am. Soc. Civ. Eng., 53: 10, 2617–43, December, 1927. This emergency dam was designed to shut off the flow of water through a lock, such as may occur when one of the lock-gates is struck by a vessel and seriously injured. The flow of water is checked by a number of transverse girders spanning the lock chamber, placed one above the other somewhat like the stop-logs in hydraulic power plants. The girders are lowered and

raised by a hoisting engine carried on a revolving crane, similar in appearance to a railroad swing bridge. The several parts of the dam are described and illustrated.—*John R. Baylis.*

Boston's High Pressure Fire System. E. E. Williamson. Jour. New Eng. Wat. Works Assoc., **41**: 3, 194, September, 1927. System very valuable to fire department, permitting rapid concentration of large number of powerful streams within area protected, lessening number of engine companies required.—*Carl Speer, Jr.*

Leaks and Litigation. George Finneran. Jour. New Eng. Wat. Works Assoc., **41**: 3, 201, September, 1927. Types, causes, and devices for locating of leaks discussed in detail. Steady increase of litigation, with excessive costs, shows need as a sound economic policy to bring all water works fixtures to high degree of safety and efficiency to avoid claims for damages to personal property.—*Carl Speer, Jr.*

Five Years of Rapid Sand Filtration at Cambridge, Mass. Whipple and Chandler. Jour. New Eng. Wat. Works Assoc., **41**: 3, 218, September, 1927. Ouality of water, turbidity, hardness, and bacterial count discussed. Treatment given this type of problem discussed in detail. Water enters valve chamber where treated with sodium aluminate; distribution chamber of coagulation basins where it receives alum or aluminum sulphate; filter beds; aërator; to distributing system. Found that coagulation must be successfully accomplished in this type of purification or serious problems arise. Coagulation basin cleaned once in four weeks under normal conditions. Results satisfactory. Filter operation, special treatment of beds, corrective treatment of corrosive properties discussed.—*Carl Speer, Jr.*

Practical Methods of Color Removal. Robert Spurr Weston. Water Works Eng., **80**: 17, 1187, August 17, 1927. Storage effective method of color removal. One instance, 2.9 to 17 per cent of color removed after period of 15 hours. Iron important factor in purification by storage. Precipitated iron is brought to the surface with the semi-annual overturns and reaërated. It then acts as a coagulant for the coloring matter. Removal of color by slow sand filtration rarely amounts to a reduction of more than 25 per cent. To reduce color to a greater degree, sulphate of alumina usually used as a coagulant with soft waters. Wide range of chemicals and treatment required for different waters with same intensity of color. Best pH value for coagulating colored waters is below 6.0. Pre-chlorination may change the coloring matter from a non-coagulable to a coagulable condition. Good mixing of chemical and water pre-requisite to coagulation. Necessary to keep coagulating basins cleaned to prevent re-solution of the sludge by the water.—*Carl Speer, Jr.*

The Volga, The Oka and The Moskowa Rivers as Sources of Supply of Potable Water for the City of Moscow. S. N. Stroganoff and N. G. Zakharoff. Résumé of Report of Communal Service of Moscow, 1927 (Russian). The

water supply of the city of Moscow comes from the underground stream of Mytizchy, providing 25,000 cubic meters per day, and 170,000 cubic meters per day are taken from the River Moskowa. The population of Moscow according to the last census is over two million. The supply is only sufficient for the metropolitan area. It is estimated that 630,000 cubic meters will be required in 1950, and in 1933 that 300,000 cubic meters will be required to supply the environs of Moscow as well. The Moscowa cannot supply more than 260,000 cubic meters per day, so a commission was appointed to find other sources of supply. Two other rivers, the Volga and the Oka, were investigated. As the distance from these rivers was 100 km. they appeared impracticable for this purpose, a more practical solution seeming to be the impounding of the Moscowa to provide a constant supply and to lessen the risk of floods as well.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst*).

Enslow Chlorine Comparator. W. A. TAYLOR. Canadian Eng., **52**: 20, 527, May 17, 1927. An illustrated description of the Enslow comparator for determining free chlorine by the o-tolidin method. The chlorine dosage required for sterilization of water is affected by the presence of organic matter or oxidizable salts, and also by the H ion concentration, as oxidation occurs more rapidly in the presence of free carbonic acid. The practical method of chlorination control is so to regulate the dosage that frequent samples, taken at point providing a 5-minute contact period, show a residual chlorine content of 0.1 to 0.2 p.p.m. Swimming pool water should contain 0.2 to 0.5 p.p.m. of free chlorine at all times. In treatment of sewage effluents and trade effluents, a residual chlorine content of up to 1.0 p.p.m. is necessary after 10 minutes contact.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Water Supply in South Wales. Anon. Surveyor, **72**: 1853, 95, July 29, 1927. This article gives an historical account and very brief description of the Taf Fechan water works, comprising an earth dam 1,010 ft. long and 107 ft. high which forms a reservoir of 3,800,000,000 Imperial gallons capacity, a "Patterson Rapid Filtration Gravity Plant" designed for 7,500,000 Imperial gallons daily, and several miles of cement lined steel pipe.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

A Study of the Water of Paper Mills. NATSUHIKO WATANABE. Jour. Public Health Asso. of Japan, **3**: 7, 1, July 1927. The author reports a number of studies and experiments made by himself on waste waters from paper mills in an effort to determine the significance of this particular industrial waste as affecting the health of the population in certain areas, its effect on fish life in streams into which it is discharged and its possible application to soil as a fertilizer-carrying irrigation water to growing crops. Three kinds of waste were experimented with which the author designates as Nos. I, II, and III as follows: (I) Straw and lime, or paper board refuse; (II) manila hemp, Broussonetia Kashinoki, Sieb and other materials used in the making of Japanese papers; (III) wastes in which above two are combined. Interesting charts and tabulations of the detailed technique, covering each type of experimental study, and the author's conclusions are given. A considerable number

of experiments were conducted with different chemical agents and varying dilutions of the waste in order to determine the most effective method of accomplishing decolorization. Dilutions of paper mill waste of varying strengths from 1:100 to 1:600 were made of fluids Nos. I, II and III and the dilutions examined as to appearance, odor, reaction, and analyzed for the presence of sulfuric and nitric acids, ammonia, chlorine, lime and organic matter. These experiments are carefully tabulated. A series of experiments were made to determine the effect of dilution alone on the putrescibility of waste waters. The effect on sanitation of the Districts along the river to which the waste waters flow (1) Mosquito breeding increased and breeding season prolonged; (2) fishing, swimming, and such recreations interfered with or made impossible. River changed from beautiful, clear stream to one of filthy, foul, malodorous character with its beauty spoiled. Fish entirely destroyed; (3) a variety of gases are generated in the water. Air along the river bank contained 1 part per 3,000,000 of hydrogen sulfide. The foul odor varies according to the day, hour and place. It is the author's opinion that some means should be devised for using paper mill waste for fertilizer unless it can have a dilution in the stream receiving it of at least 1 to 500.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Pressure Filtration Plant. Anon. Water Works, **66**: 1, 11, January 1927. A mechanical filtration plant to remove peat stain from and counteract plumbo-solvent action in a portion of the water supply at Bradford Corporation, England, is described. The supply is from peat lands containing humic acid. Water must be treated with an alkali to prevent lead poisoning. Sulphate of alumina and lime or chalk are added for coagulation, removal of color, and neutralizing the acidity. "The decision to adopt mechanical filters in this instance was reached chiefly on account of the following considerations, viz.: (a) There is no suitable site on which to erect slow-sand or open gravity filters between the reservoir and the first point of delivery; (b) peaty discoloration can be effectively removed; (c) acidity can be readily neutralized, thus removing or reducing metallic solvency and corrosion; (d) initial cost of construction is less than that of slow-sand filters; (e) contamination from the air and the encouragement of the growth of algae are avoided as the filtrate is delivered direct to the district of supply; (f) no interruption from frost; and (g) the bacterial purification is as efficient as in slow-sand filtration. The operating and maintenance charges are higher, owing to the cost of the coagulant—sulphate of alumina—used to effect color removal, and the water used may be greater, owing to the increased burden on the mechanical filters arising from the decolorization process. But these factors are largely, if not entirely, offset by the interest received on the greatly reduced capital expenditure for the mechanical filters, which entirely remove the peaty stain and give a clean colorless water."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Filter Plant Operation at Cincinnati, Ohio. Clarence Bahlman. Water Works, **66**: 445–6, 1927. During 1925 the average *Bact. coli* index of the raw water was 1690, which was lower than average, while in 1926 it was 3075, which is the highest that it has ever been with the exception of one year.

The average index of the filter effluent was 2.48 in 1925 and 3.74 in 1926. The chlorinated plant effluent has always had annual average indices lower than 1.0 since 1920. In May 1926 the Central Service taps had an average index of 4.0 which was caused by the blowing of dry manurial dust into the Eden Park reservoir. Nauseating phenol tastes appeared in the tap water in December 1925 and remained for 32 days. In December 1926 these tastes were eliminated in 48 hours after they appeared by suspending chlorination and resorting to double coagulation and excess lime treatment. Short filter runs were experienced in September 1925 and were caused by large numbers of *Synedra delicatissima* in the raw water. The conclusions reached after experimenting with double coagulation were: (1) double coagulation without exception resulted in a lower coli index in the plant effluent; (2) with normal raw water the procedure is not needed; (3) with water abnormally high in turbidity and coli, double coagulation is very valuable; (4) with this process it is possible to produce an unsterilized water of standard quality during the warmer months if the raw water pollution be not excessive.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Pipe Line Through Quicksand. J. B. WHITE. Water Works, **66**: 443–4, 1927. A new 36-inch discharge water line was laid from the plant of the El Paso Electric Co. to the Rio Grande River. The line was 1380 feet long and was laid in ground that was largely quicksand with the ground water level from two to four feet below the surface. To lay the "Hume centrifugal process" concrete pipe it was necessary to excavate a trench 6 feet in width and varying in depth from 6 to 13 feet. It was necessary to shore the sides of the entire trench and drain the soil adjacent to the trench of all water prior to the actual digging. This was done by jetting and driving 1½-inch drive point wells on both sides of the location of the trench so that the tops of the screens were 1 foot below the level to which the trench was to be excavated. These were tied into three suction headers on each side leading to the pumps. Two and sometimes three reciprocating pumps each of 250 gallons per minute capacity were required to take care of the flow.—*C. C. Ruchhoft.*

The New Water Conduit of Fort Worth, Texas. D. L. LEWIS. Water Works, **66**: 469–70, 1927. The new conduit, which will bring the water supply from an impounding reservoir of 25 billion gallons capacity to the filtration plant in the city, is 5.5 miles long and requires a tunnel 4,400 feet long through rock and three siphons under a small river. Sixty-inch pre-cast concrete pipe in units 12.5 feet long are being installed on 22,000 feet of the line while 48-inch pipe is being used for a short section near the filtration plant. The capacity of the line will be from 33 to 55 million gllons per day depending upon the water level in the reservoir.—*C. C. Ruchhoft.*

"The World Do Move." Monthly Bulletin, Indiana State Board of Health, **30**: 2, 27, February, 1927. Ordinance of town of Ophir, Utah, made it unlawful to permit any cattle, horses, sheep, goats, or hogs to pollute any stream of water used by the inhabitants of the town, anywhere within 10 miles above point where said water was first taken by the town for domestic purposes.

State supreme court decided on June 4, 1926, that the ordinance was valid.—*G. C. Houser.*

Survey of Indiana Public Water Supplies. Monthly Bulletin, Ind. State Board of Health, **30**: 2, 29, February, 1927. In a survey of 176 Indiana public water supplies, made in January, 1927, the following were the most prevalent sanitary defects found: sources of contamination located within 300 feet of wells (46 supplies); well casings under suction (26 supplies); wells, reservoirs, etc., improperly protected (20 supplies). Of the 249 public supplies in the state, 44 were classed as treated supplies: 20 received chlorination only; 24 were treated by sedimentation, filtration and chlorination.—*G. C. Houser.*

Pure Drinking Water and Safe Disposal of Sewage. Health Bulletin. North Carolina State Board of Health, **42**: 6, 3, June, 1927. Reviews article on typhoid fever in cities of 25,000 to 250,000 population, published in March (1927) issue of Statistical Bulletin of Metropolitan Life Insurance Co. From 1900 to 1910 the mortality from typhoid fever ranged from 25 to 45 per 100,000. By 1924 the minimum typhoid death rate per 100,000 had decreased from 25 to 4. Next to the increasingly safe milk supply provided, the chief causes of this improvement were the purification of water and the extension of sewer lines.—*G. C. Houser.*

Prevent Typhoid Fever and Colitis This Summer. Health Bulletin. N. C. State Board of Health, **42**: 6, 5, June, 1927. For the person who would exercise caution when travelling away from home and partaking of water by the roadside, a very simple precaution would be to put one drop of tincture of iodine in each half-pint tumbler of drinking water, and let it stand for 20 minutes before drinking. Such a drink of water would be safe. This precaution would be desirable in giving water to babies, if it is found impossible to boil the water that they drink.—*G. C. Houser.*

The Tourist Typhoid Carrier Problem. H. W. Hill. Bulletin, Arizona State Board of Health, **42**: 16, July, 1927. Tourist camps should never be located near an open public reservoir or on a stream, especially one used for a water supply, unless every precaution to avoid polluting the stream is taken. When camping, boil all water, unless obtained from a good public water supply or a well (except in limestone country.) If inconvenient to boil water, add a solution of chloride of lime or of sodium hypochlorite to the water in such amounts as to give one part per million of chlorine. Let water stand 20 minutes before drinking.—*G. C. Houser.*

Municipal Responsibilities for Public Health Service. B. K. Richardson, Illinois Health News, **13**: 7, 205, July, 1927. During the last decade 10 epidemics of typhoid fever and dysentery, ranging from 10 to 3000 cases, have been traced to contaminated municipal water supplies in Illinois. Five of these were attributed to leaky valves at cross-connections; 4 were attributed to flood conditions that increased pollution at a time when no increased precautions were taken to sterilize the water; one was due to the use of a tile

water main which absorbed seepage from a sewer. Three years ago a storm reversed the flow of Chicago River and caused unusually heavy contamination of water. Chlorine dosage was insufficient, and 300 cases of typhoid resulted.—*G. C. Houser.*

Is Your Fair Ground a Menace to Health? C. D. Gross and H. F. Ferguson. Illinois Health News, **13**: 7, 218, July, 1927. In Illinois, typhoid fever attacks about 3,000 persons, causes about 300 deaths, and costs the people over $1,000,000 each year. Safe city water where available, should be piped and exclusively used upon fair grounds. Out of 79 fair grounds inspected in Illinois during 1926, at 29 there was only safe water available. At 22 fairs there existed both safe and dangerous water supplies, with no means for visitors to distinguish between them. At 28 fairs the only available sources of water were subject to possible pollution.—*G. C. Houser.*

Monthly Report of Epidemiologist for June, 1927. W. W. Lee. Monthy Bulletin, Ind. State Board of Health, **30**: 7, 106, July, 1927. The writer was engaged in flood relief work in Sunflower County, Miss. Relief work consisted in chlorinating wells in flooded area, vaccinating people against typhoid fever, and instructing people about cleaning their houses and draining pools left by the flood, or oiling the stagnant water which could not be drained, as a preventive against mosquitoes. Wells were cleansed as follows: 6 ounces of a 1:50 solution of hypochlorite of lime was poured into the well pipe and left there for 10 hours, after which the well was pumped until water was clear enough to drink.—*G. C. Houser.*

Connecticut Sends Relief to Flood Area. H. A. Lanpher. Conn. Health Bulletin. **41**: 7, 155, July, 1927. Water supply of Clarendon, Ark., was pumped from 2 wells, 178 and 200 feet deep. At height of flood there was 45 feet of water in the pump house. An emergency supply was obtained from a driven well, 12 feet deep. Calcium hypochlorite was added to the water. After the flood had receded sufficiently, the pumps were cleaned up, mains were flushed out, and a chlorinator was hooked on to the supply pipe. Safe supply of water was furnished 19 days after the flood.—*G. C. Houser.*

Purification of Springs and Wells. Health Bulletin. N. C. State Board of Health, **42**: 8, 25, August, 1927. U. S. Public Health Service has recently issued Hygienic Laboratory Bulletin No. 147, dealing with pollution of wells by means of the water underground. The report shows that it is the rise and fall of ground water, due to rain and drought, which permits the water to become purified. Were it not for this fact, underground water would contain pollution of considerable age, and it would be difficult to find pure spring or well water, except under an impervious layer.—*G. C. Houser.*

Brief Summary of Bacterial Methods and Standards in Water Analysis. H. W. Clark. The Commonhealth. Mass. Dept. of Public Health, **14**: 3, 78, July–August–September, 1927. In examining samples of water and sewage in Massachusetts, the department has varied the standard methods to some

extent. They discontinued many years ago the use of gelatin and incubation for 48 hours; they use instead agar and count after 4 days' incubation. In partial confirmation, so called, of coli-aerogenes group, they use litmus lactose agar instead of endo or eosin methylene blue as recommended. Author believes that, until further information is gained, any member of coli-aerogenes group, when found, should be reported as B. coli, and in addition that streptococci, when found on confirmation plates, should have same significance as B. coli.—*G. C. Houser.*

Investigation of Three Indiana Water Supplies. Monthly Bulletin, Ind. State Board of Health, **30**: 9, 145, September, 1927. In August the water supplies of Oakland City, Owensville, and Petersburg were investigated. It was determined that the Oakland City water supply, which is obtained from an artificial lake without treatment, is not fit for drinking most of the time. Owensville supply is obtained from dug wells, none of which produce satisfactory water. Petersburg supply is pumped directly from White River to the mains without treatment, and the water is not fit to drink. It is expected that work on a filtration plant for Petersburg will be started early in 1928.—*G. C. Houser.*

Standard Couplings for Fire Hydrants. Virginia Municipal Review, **4**: 10, 324, October, 1927. About 40 per cent of total number of fire-protected cities of U. S. have adopted a standard for screw thread couplings, enabling fire companies of one city to come to rescue of another, according to information made public by Bureau of Labor Statistics of Department of Labor on September 16. Work of standardization has been carried on by American Engineering Standards Committee, in which Bureau of Standards and National Screw Thread Commission have participated.—*G. C. Houser.*

Liability of Landlord for Tenant's Unpaid Water Bill. Virginia Municipal Review, **4**: 10, 331, October, 1927. In case of Etheridge *vs.* city of Norfolk, decided on September 29, 1927, the Special Court of Appeals of Virginia struck a hard blow at practice of holding the owner of property, liable for unpaid water bills of tenants. Court held unconstitutional and void an ordinance of city of Norfolk, authorizing the city's water bureau to hold the property owner responsible in such cases.—*G. C. Houser.*

The Story of Richmond's Water Works. From Richmond News Leader. Virginia Municipal Review, **4**: 10, 332, October, 1927. Present average consumption of water in Richmond is 20 m.g.d. and effective storage of reservoirs is 47 million gallons. Water is taken from James River, passed through 2 subsiding basins, treated with alum in two 15-m.g. coagulating basins, and filtered, before being pumped to the city. The filters began operation in 1924. Purification plant represents an outlay of about $1,200,000.—*G. C. Houser.*

Eastern States Coöperate for River Pollution Prevention. Health News. N. Y. State Dept. of Health, **4**: 48, 189, November 28, 1927. In October an agreement was signed by the State Health Commissioners of Illinois, Indiana,

Kentucky, Maryland, New York, Ohio, Pennsylvania, Tennessee and West Virginia. Purposes are the elimination from Ohio River and tributaries of phenol and other industrial wastes causing odors and tastes, and the notification of downstream and adjacent cities, whose officers have signed the agreement, of any unusual events, such as phenol spills and typhoid epidemics, in order that protective measures can be taken.—*G. C. Houser.*

Supervision of Public Water Supplies in Connecticut. W. J. Scott. Conn. Health Bulletin, **41**: 11, 235, November, 1927. State Department of Health is constantly making an effort to safeguard and improve the public water supplies of Connecticut by inspections of watersheds, chlorination plants, and filtration plants, investigation of complaints, surveys of adequacy of supplies, supervision of cross connections, approval of new supplies, and periodic analyses of all public water supplies.—*G. C. Houser.*

"You Never Miss the Water." Pennsylvania's Health, **5**: 6, 22, November-December, 1927. Government dredging machine in Monongahela River recently severed the supply main, through which West Brownsville is furnished with water from filter plant at Brownsville across the stream. 800 people were without a public water supply for 2 days. State Department of Health urged citizens to boil all water used for domestic purposes, and there were no disease consequences from break in main.—*G. C. Houser.*

Establishing Classifications of Public Water Supplies of West Virginia. E. S. Tisdale. Quarterly Bulletin, W. Va. State Dept. of Health, **15**: 1, 15, January, 1928. Water supplies in 154 cities of over 500 population have been classified. Good water is available in 82 cities, with a total population of 433,000. The doubtful class contains 44 public water supplies, serving 78,000 people. These water supplies have some protection, but cannot be classed as good. The bad supplies number 28 and serve 47,000 people. Major defects exist with these supplies.—*G. C. Houser.*

ABSTRACTS, SUB-COMMITTEE NO. 9

Joint Research Committee on Boiler Feedwater Studies

Water and the Corrosion of Boiler Plant. Power Engr., **23**: 262, January 1928, p. 10. Brief treatment of chemistry of corrosion; apart from scale-forming propensities of hard waters, presence of acid-forming salts and source of formation of these salts under boiler conditions are important items when considering corrosion of boiler plates and tubes.

Experiences with 1,300 Lbs. Steam Pressure. J. Anderson. Eng. and Boiler House Rev., **41**: 7, January 1928, pp. 324–327, 3 figs. Calculations covering range of service conditions as regards heat-transfer rates, velocity of water in tubes, and thickness of scale, indicated that 900 deg. tube temperature could occur under actual operating conditions with scale of $\frac{1}{16}$ inch thickness; loss of tensile strength in service. (Continuation of serial.)

Use of Phosphate Rock "Floats" as an Anti-Scale Material for Boilers. A. G. Doe. U. S. 1,639.027, August 16. Chem. Abstracts, October 10, 1927, 21: 3243.

The Boiler-Scale Problem Solved. Anon. Petroleum World (London), 24: 194–5, 1927. Chem. Abstracts, October 10, 1928, 21: 3243. An apparatus, the "Filtrator," is described, which produces an organic colloid which is stable in boiler-feed water.—*M. B. Hart.*

Internal Corrosion of Fuel Economizers. E. Ingham. Mech. Wld., 82: 2138, December 23, 1927, p. 467. Corrosion caused by pure water is generally believed to be due to presence in water of dissolved gases, oxygen, or carbonic acid; corrosion may be avoided by using pure water entirely free from dissolved gases; a great deal may be done to prevent corrosion due to presence of dissolved gases in feedwater by introducing with feed certain reagents; remarks are confined to ordinary cast-iron economizer.

Boiler Water Tests Should Be Utilized. Joos, I. C. E. Power Plant Eng., 31: 769–71, 1927. Chem. Abstracts, November 20, 1927, 21: 3998. Description of apparatus and methods for making hardness and chloride determinations in boiler feed water. II. Ibid., 895–7.—The analyses form the basis for checking leaky blow-off valves and broken baffles and for determining scale removal or formation while boilers are in operation.—*S. D. Poarch.*

Feedwater Temperatures Show Increase. Power Plant Eng., 32, 1, January 1, 1928, pp. 31–32, 4 figs. Stage heating and heat-recovery methods mark trends in boiler-feedwater heating; savings are secured by high feed heating.

On Triple Heating of Feed Water of 18,900 Type Locomotive and Sekomoto's Variable Nozzle. G. Sekomoto and K. Tomita. (Japan) Dept. of Railways—Bul., 15: 11, November 1927, pp. 1775–1793, 9 figs. See also succeeding article by same authors entitled, **Results of Test on Sekomoto's Variable Nozzle of Locomotive,** pp. 1794–1800, 4 figs. (In Japanese.)

A Physicochemical Study of Scale Formation and Boiler-Water Conditioning. Hall, R. E., Smith, G. W., Jackson, H. A., Robb, J. A., Karch, H. S. and Hertzell, E. A. Mining and Metallurgical Investigations, Carnegie Inst. Tech. and Bur. Mines, Bull. 24: xiii × 239 pp. (1927). Chem. Abstracts, October 20, 1927, 21: 3407.

Removal of Oil from Boiler-Feed Water and Water for Making Ice. Jungwirt, H. Chem. App. 14: 194–6, 1927; 3 cuts. Chem. Abstracts, November 10, 1927, 21: 3694. Dijxhoorn's method (C. A. 20: 1482) is described.—*J. H. Moore.*

Boiler Water Treatment. V. T. Edquist. Chem. Eng. and Min. Rev., 20: 230, November 5, 1927, pp. 43–45, 2 figs. Sons of Gwalia mine in Western Australia is situated about 140 miles north from Kalgoorlie in arid country;

water for domestic, boiler and power purposes is pumped from number of shallow outlying wells; when this water is used in boilers in natural state it is scale-forming and intensely corrosive; treatment is by lime-barium, crude witherite being used as source of barium.

Sodium Aluminate as an Aid to Water Softening. Am. Ry. Eng. Assn.—Bul., **29**: 300, October 1927, pp. 138–142. Use of sodium aluminate on the Rock Island lines; table showing additional savings resulting from use of sodium aluminate in lime and soda plants.

Testing Treated Feedwater. Power Plant Eng., **32**: 1, January 1, 1928, pp. 30–31, 1 fig. Regular routine tests are made and records kept as guide to operation; titration provides simple method; control of blowdown secured by tests.

Tests of Raw Water Involve Many Processes. Power Plant Eng., **32**: 1, January 1, 1928, pp. 26–27, 1 fig. Following careful analysis of water, regular routine tests are made by power-plant personnel and records kept; tests should be made for following: Total alkalinity, carbonate, bicarbonate, and hydrate alkalinity, hydrogen-ion concentration, chlorides, dissolved oxygen, total solids, suspended solids, turbidity, and total hardness.

Boiler-Feed Water Problems and Methods of Treatment. Powell, S. T. Mech. Eng., **49**: 1009–12, 1927; cf. C. A. **20**: 3762. Chem. Abstracts, October 20, 1927, **21**: 3408.—*J. A. Kennedy.*

Practical Feedwater Treatment (Beitraege zur praktischen Speisewasserpflege). Zeit. des Bayerischen Revisions-Vereins, **31**: 23, December 15, 1927, pp. 251–253. Rules to be followed in operation and control of water purifiers; requisite properties of purified water and feedwater. (To be concluded.)

Purification and Treatment of Feedwater. S. T. Powell. Power Plant Eng., **32**: 1, January 1, 1928, pp. 24–26. Present tendencies in methods of testing feedwaters and their subsequent purification and treatment for use in modern power-plant boilers are toward combination of systems; continuous blow-down methods and adoption of zeolite process increasing in use; electrolytic methods have possibilities.

A Method of Feedwater Treatment. Gas Engr., **43**: 620, December, 1927, pp. 323–324. Non-chemical method called "Filtrator" system used at Weston-super-Mare, England; introduces small stream of colloid substances into feedwater or boiler; source of "colloid" is commercial uncrushed linseed; cost very small compared to water-softening plant, and effect as good.

Treat Feedwater for Its Specific Duty. Power Plant Eng., **32**: 1, January 1, 1928, pp. 27–30. 5 figs. It is claimed that treatment methods should be individually determined; factors involved in choice of filter; concentration control; corrosive action reduced by degasification.

Progress in Steam Power Engineering. J. A. Hunter. Power, 67: 3, January 17, 1927, pp. 121–122. Abstract of report of Power Division of Am. Soc. Mech. Engrs., dealing with boilers, methods of firing, steam piping and feedwater treatment, turbines, mercury-vapor process and industrial power.

Sand Filter Plant, Launceston, Tasmania. G. D. Balsille. Commonwealth Engr., 15: 3, October 1927, pp. 95–98. Experience gained in last two years is outlined in paper read before Commonwealth Conference on Public Health held in Melbourne; general description of plant and its operation.

Foaming of Locomotive Boilers, with Special Reference to Influence of Suspended Matter on Foaming, and Cost of Blowdown Am. Ry. Eng. Assn. Bul., 29: 300, October 1927, pp. 143–157, 3 figs. Problem is to determine cause of foaming in locomotive boilers and also other causes of wet steam; for foaming tests, boilers must be divided into three classes; stationary, road locomotives and switch engines; instructing enginemen as to amount of water to be blow off; charts illustrating conditions of water from locomotive boilers on Chicago & Alton R. R.

Removal of Sulphur from Well Water is Problem Confronting Beverly Hills. R. L. Derby. Hydraulic Eng., 3: 12, December 1927, pp. 17 and 42, 1 fig. Extensive experimental work conducted by City leads to construction of large filtration plant; construction of spray head; effects of retention; main transmission line; filtration; lime treatment.

Results of Recent Investigations in Water Purification (Neue Forschungsergebnisse auf dem Gebiete der Trinkwasserversorgung), J. Tillmans. Zeit. fuer Angewandte Chemie, 40: 51, December 22, 1927, pp. 1533–1539, 3 figs. Summarizes recent progress in deferrization and demanganization processes for potable water; pipe corrosion by water containing oxygen and by water free of oxygen; natural protective coatings formed by water and injurious effect of oxygen and carbonic acid upon it.

Water Purification Progress During 1927. N. J. Howard. Contract Rec. and Eng. Rev., 41: 52, December 28, 1927, pp. 1346–1350. Improvements in methods of treating, pollution of water sources, double filtration gaining; increasing consumption in unmetered cities; new plants built during year; automatic rate controller, wash water recovery; chemical treatment of unfiltered water, alum treatment at Sacramento, aeration, prevention of goitre, taste removal; typhoid rate declines; changes in methods of water analysis.

What is the Best Rate of Filtration? R. B. Simms. Water Wks. Eng., 81: 1, January 4, 1928, pp. 19–20. Author suggests rate of 125,000,000 gallon per acre per day and where raw water is only slightly polluted and is of low turbidity, 150 million gallon per acre per day; loss of head; wash water; rate of flow in wash-water line.

Coagulation Studies at the Washington Surburban Sanitary District. R. B. Morse, C. A. Hechmer and S. T. Powell. Indus. and Eng. Chem., **20**: 1, January 1928, pp. 56–59. Experience gained at two plants during past few months has indicated clearly that combined treatment of small quantities of sodium aluminate with alum has specific value in treatment of water, especially during periods when raw water contains much colloidal clay.

Effect of Salts on the Rate of Coagulation and the Optimum Precipitation of Alum Floc. H. Peterson and E. Bartow. Indus. and Eng. Chem., **20**: 1, January 1928, pp. 51–55, 3 figs. Alum floc is gelatinous substance, highly adsorptive, amphoteric and relatively insoluble over wide range of hydrogen-ion concentration.

NEW BOOKS

The Chemistry of Water and Sewage Treatment. Arthur M. Buswell. American Chemical Society Monograph Series. Book Department. The Chemical Catalogue Company, Inc. 1928. During the past twenty years an enormous amount of experimental work has been conducted on problems relating to water and sewage treatment. As a result of these various studies, the earlier concepts of the chemical phenomena have undergone radical changes. A vast amount of related material has appeared in the technical press, but no previous effort has been made to correlate these voluminous data. Dr. Buswell has shown a keen understanding of this phase of sanitary science and has presented the recent developments in this field in an intelligent and orderly manner.

It should be refreshing to any student of public health engineering to have available for reference current knowledge on the many controversial phases of the problem, accurately transcribed and so compiled as to be of practical value. The author has accomplished this difficult task exceptionally well. Possibly the most valuable portions of the text are those chapters dealing with the structure of atoms and theory of valence; colloids; chemistry of coagulation; the nitrogen cycle; sludge digestion and the microbiology of colloid removal. The author has wisely embodied in the text only such engineering discussions of these problems as might be considered necessary to demonstrate current practice based upon fundamental principles developed, as a result of construction experimentation. The text reflects the author's wide experience in the field, but nowhere has there been indicated any lack of appreciation of the efforts of other coworkers.

As a reference text on the subject, the book has much merit. There are surprisingly few typographical errors and the cuts and half-tones are well done. The text possesses also the additional value that the tabulated material has been compiled in a form that is readily followed by the reader and that may well be emulated by others.—*S. T. Powell.*

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